WITH THE COMPLIMENTS OF

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J. B. W[illegible]

MARYLAND GEOLOGICAL SURVEY

UPPER CRETACEOUS

TEXT

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LETTER OF TRANSMITTAL

To His Excellency PHILLIPS LEE GOLDSBOROUGH,

Governor of Maryland and President of the Geological Survey Commission,

Sir:—I have the honor to present herewith the sixth volume of a series of reports dealing with the systematic geology and paleontology of Maryland. The preceding volumes have dealt with the Devonian, Lower Cretaceous, Tertiary, and Quaternary deposits, and the remains of animal and plant life which they contain. The present volume treats of the Upper Cretaceous deposits and their contained life, a knowledge of which is very important from an educational and scientific standpoint. I am,

Very respectfully,

WILLIAM BULLOCK CLARK,

State Geologist.

JOHNS HOPKINS UNIVERSITY,

BALTIMORE, *December*. 1915.

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PREFACE

The present volume is the sixth of a series of reports dealing with the systematic geology and paleontology of Maryland, the Devonian, Lower Cretaceous, Eocene, Miocene, and Plio-Pleistocene deposits having already been fully described.

The Upper Cretaceous deposits which form the subject-matter of the present volume are extensively developed in the Maryland area, and the Maryland section is the type for the Middle Atlantic Coastal Plain. Similarly the faunas and floras of the Upper Cretaceous are fully represented.

The Upper Cretaceous deposits are described by Professor Wm. Bullock Clark, of the Johns Hopkins University, who has devoted many years to a study of the Cretaceous of the Atlantic Coastal Plain. The chapter on Petrography and Genesis of the Sediments is contributed by Dr. Marcus I. Goldman, a former student of the Johns Hopkins University.

The paleontological investigations have been jointly conducted by several experts. The Vertebrata, and the fossil plants, which are especially prominent in the Magothy formation, have been described by Professor Edward W. Berry, of the Johns Hopkins University, who has also contributed the chapter on the Upper Cretaceous Floras of the World. The abundant molluscan faunas of the Matawan and Monmouth formations have been described by Dr. Julia A. Gardner, of the Johns Hopkins University. The Arthropoda have been described by Dr. Henry A. Pilsbry, of the Philadelphia Academy of Natural Sciences; the Bryozoa by Dr. R. S. Bassler, of the U. S. National Museum; the Echinodermata by Professor Wm. Bullock Clark; and the Anthozoa by Dr. L. W. Stephenson, of the U. S. Geological Survey.

Grateful acknowledgment is made to all who have assisted in the present study; especially to Mr. A. B. Bibbins of Baltimore for much information regarding the stratigraphy of the Raritan and Magothy formations, and to Dr. T. W. Stanton and Dr. L. W. Stephenson for

facilities at the U. S. National Museum, and for much critical advice in connection with the account of the Mollusca; to Dr. Henry A. Pilsbry for assistance and for the use of the rich collections of the Philadelphia Academy of Natural Sciences; to Dr. H. B. Kümmel, the State Geologist, and Dr. M. W. Twitchell, the Assistant State Geologist of New Jersey, for the use of the collections of the Geological Survey of New Jersey; and to Mr. George S. Barkentin, of Albany, New York, for the beautiful drawings which illustrate the Vertebrata, Mollusca, Brachiopoda, and Echinodermata. Acknowledgment is also made to Mr. A. B. Bibbins for several of the photographs of characteristic Upper Cretaceous outcrops.

THE UPPER CRETACEOUS DEPOSITS OF MARYLAND

THE UPPER CRETACEOUS DEPOSITS OF MARYLAND

BY

WM. BULLOCK CLARK

INTRODUCTION

The Upper Cretaceous deposits of Maryland can only be interpreted through an understanding of the physiography and geology of the broad province of which the State of Maryland forms a part. The physical features which characterize this area may be traced for varying distances into adjoining regions, some being recognized as far as the New England coast on the north, and others as far as the Gulf Region on the south.

The Physiography

The region here considered forms a portion of the Atlantic slope, which stretches from the crest of the Alleghanies to the sea, and which is divided into three more or less sharply defined regions known as the Coastal Plain, the Piedmont Plateau, and the Appalachian Region. These three districts follow the Atlantic border of the United States in three belts of varying width from New England southward to the Gulf. Maryland is, therefore, closely related in its physiographic features to the states which lie to the north and south of it, while its central location on the Atlantic border renders it perhaps the most characteristic in this broad tract. In crossing the three districts from the ocean border the country rises at first gradually, and then more rapidly, until it culminates in the highlands of the western portion of the state.

The *Coastal Plain* is the name applied to the low and partially submerged surface of varying width extending from Cape Cod southward

through Florida, and confined between the Piedmont Plateau on the west and the margin of the continental shelf on the east. The line of demarkation between the Coastal Plain and the Piedmont Plateau is sinuous and often ill-defined, for the one frequently passes over into the other with insensible topographic gradations, although the origin of the two districts is quite different. A convenient, although somewhat arbitrary, boundary between the two regions in the Maryland area is furnished by the Baltimore and Ohio Railroad in its extension from Wilmington southwestward through Baltimore to Washington. The eastern limit of the Coastal Plain is at the edge of the continental shelf. This is located about 100 miles off shore at a depth of approximately 100 fathoms beneath the surface of the Atlantic Ocean. It is in reality the submerged border of the North American continent, which extends seaward with a gently sloping surface to the 100-fathom line. From this point there is a more rapid descent to a depth of 3000 fathoms, where the continental rise gives place to the oceanic abyss.

The Coastal Plain, therefore, falls naturally into two divisions, a submerged or *submarine division* and an emerged or *subaërial division*. The seashore is the boundary line which separates them. This line of demarcation, although apparently stationary within narrow limits, is in reality very changeable, for during the past geologic ages it has migrated back and forth across the Coastal Plain, at one time occupying a position well over on the Piedmont Plateau, and at another far out at sea. At the present time there is reason to believe that the sea is encroaching on the land by the slow subsidence of the latter, but a few generations of men is too short a period in which to measure this change.

The subaërial division is itself separable in Maryland into the Eastern Shore and the Western Shore. These terms, although first introduced to designate the land masses on either side of Chesapeake Bay, are in reality expressive of a fundamental contrast in the topography of the Coastal Plain. This difference gives rise to an Eastern Shore and a Western Shore type of topography. Chesapeake Bay and Elk River separate the two. Areas showing the Eastern Shore type are found along

the margin of the Western Shore at intervals as far south as Herring Bay, and again from Point Lookout northwestward along the margin of the Potomac River. On the other hand, an outlier of the Western Shore type of topography is found at Grays Hill, in Cecil County, at the northern margin of the Eastern Shore. The Eastern Shore type of topography consists of flat, low, and almost featureless plains, while the Western Shore is a rolling upland, attaining four times the elevation of the former, and resembling oftentimes the topography of the Piedmont Plateau much more than that of the typical Eastern Shore. It will be seen later that these two topographic types, which at once strike the eye of the physiographer as being distinctive features, are in realty not as simple as they first appear, but are built up of a complex system of terraces dissected by drainage lines.

The Coastal Plain of Maryland, with which most of the State of Delaware is naturally included, is separable from that of New Jersey by the Delaware River and Delaware Bay, and from that of Virginia by the Potomac River, but these drainage ways afford no barriers to the Coastal Plain topography, for the same types with their systems of terraces exist in New Jersey and Virginia as well as in Maryland.

The Chesapeake Bay, which runs the length of the Coastal Plain, drains both shores. From the Western Shore it receives a number of large tributaries which are in the process of developing a dendritic type of drainage, and which have cut far deeper channels than have the rivers of the Eastern Shore. If attention is now turned to the character of the shore-line, it will be seen that along Chesapeake Bay it is extremely broken and sinuous. A straight shore-line is the exception, and in only one place, from Herring Bay southward to Drum Point, does it become a prominent feature. These two classes of shore correspond to two types of coast. Where the shore is sinuous and broken, it is found that the coast is low or marshy, but where the shore-line is straight, as from Herring Bay southward to Drum Point, the coast is high and rugged, as in the famous Calvert Cliffs which rise to a height of 100 feet or more above the Bay. The shore of the Atlantic Ocean is composed of a

long line of barrier beaches which have been thrown up by the waves and enclose behind them lagoons flushed by streams which drain the seaward slope of the Eastern Shore.

It was stated in the early part of this chapter that the topography of the Coastal Plain is in reality more complex than at first appears, and that this complexity is due to a system of terraces out of which the region is constructed. The subaërial division of the Coastal Plain contains four distinct terraces and part of another, while the submarine as far as known, contains one only. This makes for the Coastal Plain, as a whole, a group of five terraces. These terraces, beginning with the highest, are known by the names of Brandywine, Sunderland, Wicomico, Talbot, and Recent. All five of the subaërial terraces are found on the Western Shore, while only three of them occur on the Eastern Shore. These terraces wrap about each other in concentric arrangement, and are developed one above another in order of their age, the oldest standing topographically highest.

THE GEOLOGY

The area of low land and shallow sea floor which borders the Piedmont Plateau on the east and passes with constantly decreasing elevation eastward to the margin of the continental shelf has been described under the name of the Coastal Plain. It is made up of geological formations of late Mesozoic and Cenozoic age. These later formations stand in marked contrast to the older strata to the westward, in that they have been but slightly changed since they were deposited. Laid down one above another upon the eastern flank of the Piedmont Plateau, when the sea occupied the present area of the Coastal Plain, these later beds form a series of thin sheets that are inclined at low angles seaward, so that successively later formations are encountered in passing from the inland border of the region toward the coast. Oscillation of the sea floor, with some variation both in the angle and direction of tilting, went on, however, during the period of Coastal Plain deposition. As a result the stratigraphic relations of these formations, which have gen-

erally been held to be of the simplest character, possess in reality much complexity along their western margins, and it is not uncommon to find that intermediate members of the series are lacking, as the result of transgression, so that the discrimination of the different horizons, in the absence of fossils, often requires the utmost care.

The Coastal Plain sediments were laid down after a long break in time following the deposition of the red sandstones and shales (Newark formation) of late Triassic age, which overlie the crystalline rocks of the western division of the Piedmont Plateau, and complete the sequence of geological formations found represented in Maryland and Delaware. From the time deposition opened in the coastal region during early Cretaceous time to the present, constant sedimentation has apparently been going on, notwithstanding the fact that frequent unconformities appear along the landward margins of the different formations.

The formations consist of the following:

FORMATIONS OF THE COASTAL PLAIN

Cenozoic.		
Quaternary.		
Recent.		
Pleistocene	Talbot	= Columbia Group.
	Wicomico	
	Sunderland	
Tertiary.		
Pliocene (?)	Brandywine	
Miocene	St. Mary's	= Chesapeake Group.
	Choptank	
	Calvert	
Eocene	Nanjemoy	= Pamunkey Group.
	Aquia	
Mesozoic.		
Cretaceous.		
Upper Cretaceous	Rancocas.	
	Monmouth.	
	Matawan.	
	Magothy.	
	Raritan.	
Lower Cretaceous	Patapsco	= Potomac Group.
	Arundel	
	Patuxent	

CRETACEOUS

Lower Cretaceous

The Lower Cretaceous is represented by the Potomac Group, which consists of the Patuxent, Arundel, and Patapsco formations, deposits laid down under estuarine and fluviatile conditions. The three formations have only been recognized in their full development in Maryland, the lowermost Patuxent formation not being found to the north of Maryland but extending southward as the basal division of the Coastal Plain series through the south Atlantic States to eastern Alabama, while the uppermost Patapsco formation extends northward into Pennsylvania and disappears southward in central Virginia. The Arundel formation has been recognized in Maryland alone.

The three formations are unconformable to each other and the underlying and overlying formations. They consist chiefly of sands and clays, the former frequently arkosic, while gravel beds are found at certain points where the shoreward accumulations are still preserved. The deposits of the Patuxent formation consist mainly of sand, often arkosic, and at times argillaceous, although clay beds at times appear. The Arundel formation consists largely of clays, frequently dark colored, and affording in places large amounts of nodular carbonate of iron. At times the deposits are very carbonaceous. The Patapsco materials consist largely of highly colored and variegated clays which grade over into lighter colored sandy clays and also at times into sands.

The organic remains consist largely of fossil plants, although the Arundel formation has afforded representatives of several orders of Reptilia together with a few invertebrate fossils. The fossil plants in the Patuxent and Arundel formations consist chiefly of ferns, cycads, and conifers, while the Patapsco formation contains a considerable representation of dicotyledonous types. Messrs. Berry and Lull, who have studied the plant and animal remains, regard them as characteristic of the Lower Cretaceous. The fossil plants of the Patuxent and Arundel are strongly Neocomian-Barremian in character, while those of the Patapsco are distinctly Albian.

The total average thickness of the Lower Cretaceous formations in Maryland is between 600 feet and 700 feet, and they show an average dip of about 40 feet in the mile to the southeast.

Upper Cretaceous

The deposits referred to the Upper Cretaceous comprise the Raritan, Magothy, Matawan, Monmouth, and Rancocas formations. The two lower formations are chiefly estuarine and fluviatile in origin, while the overlying formations are distinctly marine. All of these formations can be traced to the northward into Delaware and New Jersey, where they attain an even larger development than in Maryland. To the southward they are gradually overlapped, one after the other, by the Tertiary formations and are unknown in Virginia. Similar deposits are found in North Carolina and the States which lie to the south of it, but are known under other formational names, although probably continuous beneath the cover of Tertiary deposits.

The Upper Cretaceous formations form an apparently unconformable series resting unconformably upon the Patapsco formation of the Lower Cretaceous. The deposits consist chiefly of sands and clays, with some gravels in the two lower formations, while the three higher formations consist more particularly of clays and sands, the latter often somewhat glauconitic, although much less so than similar deposits in New Jersey. The Raritan formation consists chiefly of thick-bedded and light-colored sands with some gravels. Clays generally light in color occur in the lower portion of the formation. The Magothy formation is made up of sands and clays that change rapidly both horizontally and vertically. Finely laminated clays with alternating sand layers and often more or less carbonaceous likewise occur. The Matawan formation is composed of micaceous, sandy clays somewhat more sandy in the upper portion and more argillaceous in the lower portion of the formation. The Monmouth formation consists of reddish and pinkish sands more or less glauconitic in character. The Rancocas formation, which outcrops in Delaware near the Maryland line, consists of greensand marls which are frequently highly calcareous.

The organic remains consist chiefly of fossil plants in the Raritan and Magothy formations, and of fossil invertebrates in the Matawan, Monmouth and Rancocas formations. The flora consists largely of dicotyledonous types, those forms found in the Raritan formation being distinctly Cenomanian in character, while those of the Magothy are apparently Turonian in age, which is apparently also the age of the Matawan invertebrates. The Monmouth fauna, corersponding to the Ripley fauna of the Gulf, is universally regarded as of Senonian age, while the overlying Rancocas fauna has been referred to the Danian.

The total average thickness of the Upper Cretaceous formations of Maryland is about 400 feet. They show a dip of from 25 feet to 35 feet in the mile to the southeast.

TERTIARY

Eocene

The Eocene is represented by the Pamunkey Group, which consists of the Aquia and Nanjemoy formations. The deposits are of marine origin and comprise part of a geologic province embracing Virginia, Maryland, and Delaware.

The two formations constitute an apparently conformable series which overlies the Upper Cretaceous deposits in Maryland unconformably while in Virginia it has transgressed the latter and is found overlying the Lower Cretaceous strata unconformably. The deposits consist chiefly of greensands which are often calcareous in the Aquia formation and generally argillaceous in the Nanjemoy formations.

The fossils consist mainly of animal remains and comprise an extensive fauna, embracing particularly the molluscs and corals, which show a faunal relationship with the Wilcox and probably with the lower Claiborne beds of the Gulf.

The total thickness of the Eocene deposits in Maryland is about 225 feet, and they show an average dip of 12½ feet in the mile to the southeast.

Miocene

The Miocene deposits of Maryland are represented by the Chesapeake Group, which is made up of the Calvert, Choptank, and St. Mary's formations.[1] These formations are chiefly of marine origin. They attain a very extensive development in the drainage basin of Chesapeake Bay, both in Maryland and Virginia, from which area they can be traced southward into North Carolina and northward into Delaware and New Jersey. To the south of the Hatteras axis the conditions change materially, and other formations presenting faunal affinities more or less close are found.

The several formations comprising the Miocene are apparently slightly unconformable to each other, although this unconformity is oftentimes not apparent, the Choptank in some areas being apparently conformable to the Calvert, while the St. Mary's seemingly presents the same relations to the Choptank. The deposits of the Chesapeake Group consist largely of sands, clays, and marls. The Calvert is in part sandy and in part clayey, with extensive deposits of diatomaceous earth in the lower or Fairhaven member, and numerous marl beds packed with molluscan shell remains in the upper or Plum Point member. The Choptank formation is essentially sandy, although clays and marls also occur. The St. Mary's formation is decidedly clayey with sands or sandy clays, the latter typically greenish-blue in color and often containing large quantities of fossils.

The organic remains consist largely of fossil invertebrates, by far the most common being molluscs. Diatoms are very common, and remains of land plants are not rare in the basal strata, while corals, bryozoans, and echinoderms are not infrequent. Many cetacean forms have been found at some localities.

The thickness of the Miocene deposits is between 450 feet and 500 feet, and the strata have an average dip of 10 feet in the mile to the southeast.

[1] Another formation, the Yorktown, occurs at the summit of the Chesapeake Group in Virginia and North Carolina.

Pliocene (?)

The supposed Pliocene is represented by the Brandywine formation which, under the name of Lafayette, has been considered as extending from the Gulf along the Atlantic border region as far northward as Pennsylvania, where the last remnants are found; but recently the Gulf Lafayette has been shown to be made up of the weathered surface materials of many different formations. It is chiefly developed as a terrace lying irregularly and unconformably on whatever older formation chances to be beneath it, whether along the margin of the Piedmont Plateau or the Coastal Plain.

Few fossils have been found, and those not sufficiently distinctive to determine its age. It is known to be younger than the latest Miocene on which it rests and older than the oldest beds hitherto regarded as Pleistocene found in its immediate vicinity. It may be either Tertiary or early Quaternary in age, although most authors hitherto have regarded it as probably Pliocene in age.

The materials comprising the Brandywine formation consist of clay, loam, sand, and gravel, which are often highly ferruginous, the iron being often present in the deposits in sufficient amount to act as a cement. These materials are generally very imperfectly sorted. The deposits rarely exceed 50 feet in thickness, and have a southeasterly dip of only a few feet in the mile.

QUATERNARY

Pleistocene

The Pleistocene deposits consist of a series of surficial materials known under the name of the Columbia Group, which has been divided in Maryland and adjacent States into the Sunderland, Wicomico, and Talbot formations. They consist mainly of a series of terraces which wrap about the Lafayette and the lower portions of the older formations, and hence extend as fluviatile deposits up the stream courses.

Fossils have been found particularly in the latest, or Talbot formation, where extensive shell beds of estuarine and marine origin are known. Fossil plants have been found in all the formations. Their

FIG. 1.—VIEW OF WHITE ROCKS, PATAPSCO RIVER, SHOWING INDURATED SANDSTONE LEDGES OF RARITAN FORMATION.

FIG. 2.—VIEW OF ROCKY POINT, MOUTH OF BACK RIVER, SHOWING INDURATED SANDSTONE BED IN THE RARITAN FORMATION.

general similarity has made it impossible to establish distinctive floras as a basis for the correlation of the several formations, and their discrimination has been based mainly on physiographic grounds.

The materials consist of clay, loam, sand, gravel, peat, and ice-borne boulders. These do not occur as a rule in very definite beds, but grade into each other both vertically and horizontally. The coarser materials are often cross-bedded, and are for the most part confined to the lower portion of each of the formations, while the finer materials, particularly the loam, are commonly found in the upper part of the formations, although these conditions are by no means universal. Each of the formations rarely exceeds 25 feet or 30 feet in thickness, although under exceptional conditions a thickness of two or three times that amount occurs.

Recent

The Recent deposits embrace chiefly those being laid down to-day over the submarine portion of the Coastal Plain, and along the various estuaries and streams. To these must also be added such terrestrial deposits as talus, wind-blown sand, and humus. In short, all deposits which are being formed to-day under water or on the land by natural agencies belong to this division of geological time.

The Recent terrace now in process of formation along the ocean shore-line and in the bays and estuaries is the most significant of these deposits, and is the latest of the series of terrace formations which began with the Lafayette, the remnants of which to-day occupy the highest levels of the Coastal Plain, and which has been followed in turn by the Sunderland, Wicomico, and Talbot.

A deposit of almost universal distribution in this climate is the humus or vegetable mold, which being mixed with the weathered surface of the underlying rocks forms our agricultural soils. The intimate relationship, therefore, of the soils and underlying geological formations is evident.

Other accumulations in water and on land are going on about us all the time, and with those already described represent the formations of Recent time.

HISTORICAL REVIEW.

The Upper Cretaceous formations of Maryland were not generally recognized as such until a very late period in the investigation of the Atlantic Coastal Plain strata. Even after the Cretaceous age of the lower part of the deposits had been recognized they were associated with the underlying beds which were commonly regarded as Lower Cretaceous, or even in part as Jurassic. The upper beds of the series were, on the other hand, often associated with the overlying Eocene deposits with which in certain places they present much similarity in lithological character. It was not until a relatively recent period that the Upper Cretaceous age of the greater part of these deposits was recognized.

Some of the earlier American geological writings refer in a general way to the territory under discussion. William Maclure in his "Observations on the Geology of the United States, explanatory of a Geological Map," in 1809 mentions the region, although in this publication the entire Coastal Plain is referred to the "alluvial formation," the fourth of the grand divisions of the geological column according to the Wernerian classification which Maclure adopted.

Another early publication in which the district under discussion was mentioned is that of H. H. Hayden entitled: "Geological Essays; or an Inquiry into some of the Geological Phenomena to be found in various parts of America and elsewhere." This early publication by a Maryland man was published in Baltimore in 1820.

Gerard Troost in 1821 discusses the occurrence of amber on the Magothy River in Anne Arundel County in deposits now referred to the Magothy formation. In this article the author refers to the geological occurrence of the amber and to the associated minerals and fossils.

By far the most important contribution to the stratigraphy of the Coastal Plain that had up to that time appeared was made by John Finch in his "Geological Essay on the Tertiary Formations in America." This was the first attempt to correlate the deposits of the Coastal Plain on scientific grounds, and although many comparisons of doubtful value were made, yet the knowledge of American Coastal Plain formations was

materially advanced. Finch objects to the use of the term "alluvial" for these formations and states that they are "contemporaneous with the newer Secondary and Tertiary formations" of France, England, and other countries.

The credit for the first definite recognition of the Cretaceous deposits of the Atlantic Coastal Plain must be ascribed to Lardner Vanuxem. The results of his observations were placed in the hands of his friend, S. G. Morton, for publication in the Journal of the Academy of Natural Sciences of Philadelphia, where they appeared in 1829. His views were more briefly stated under his own signature in the American Journal of Science later the same year. During the same year, as well as in the year immediately succeeding the publication of Vanuxem's articles, several contributions were made by S. G. Morton, both in the Journal of the Academy of Natural Sciences of Philadelphia and the American Journal of Science on the organic remains of the Cretaceous deposits of various portions of the country to which he gave the name of "Ferruginous Sand Formation." Several forms from the Chesapeake and Delaware Canal were described. The results of his investigations were finally combined in 1834 in an important work entitled, "Synopsis of the Organic Remains of the Cretaceous Group of the United States." The year following, Morton proposed a division of the Cretaceous of the United States into three groups, and this view was further stated in 1842. The uppermost of these groups, however, is now generally regarded as of Tertiary age.

In 1834 the first State Geological Survey of Maryland was organized under the direction of J. T. Ducatel as State Geologist, and in his report for the year 1835 he makes the first definite statement of the occurrence of Upper Cretaceous marine deposits in Maryland by referring to the presence of "Jersey marl" in Cecil and Kent counties, although he brings forward no paleontological evidence in support of his claim. He further adds in regard to the wider distribution of the Cretaceous that "we should be cautious not to arrive at general conclusions too hastily."

In his report for 1836 Ducatel says: "It will be recollected that at the

deep cut of the Delaware Canal, lignite and amber were found by Dr. Morton, associated with ammonites, *Bacculites* and other organic remains of the Secondary epoch. None of these fossils are known to have been detected in our beds; but they have not been so deeply penetrated into, nor so carefully examined. The great deposit of Lignites and Pyrites with amber, on the Magothy River [Anne Arundel County], bears, on the other hand, all the evidences of being a member in the formation to which the micaceous black sand of the Severn [Anne Arundel County], undoubtedly Secondary, is a part." Again, in his report for 1837 he adds in regard to the section on the "Eastern Shore" at the head of the Sassafras River, that "at George Town [Kent County] the high river banks are composed of a ferruginous sand, in some places indurated, overlying a mixed green sand, without fossils; but on ascending the river the green sand is freer from foreign admixture, and at the Head of Sassafras becomes quite pure and filled with marine shells, the principal kinds of which are the *terrebratula Harlani* and *gryphea vomer*."

During part of the period that Ducatel was conducting the Geological Survey of Maryland, J. S. Booth was State Geologist of Delaware. The results of the latter's work were finally summarized in 1841 in his "Memoir of the Geological Survey of the State of Delaware," in which he divided the "Upper Secondary" of the Delaware area into the "Red Clay" and the "Green Sand" formations.

The visit of Charles Lyell to the United States in 1841 was an important event in the history of Coastal Plain geology. The inspiring presence of the author of the epoch-making "Principles of Geology," coupled with his wide knowledge regarding similar deposits in Europe, led to renewed activities in the field of Coastal Plain geology and the better interpretation under his leadership of many points which had up to that time been but imperfectly understood. Although Lyell's observations were more significant in the field of Tertiary than that of Cretaceous geology, still numerous references were made to the latter. In his contributions to the subject he correlated the American Cretaceous with the divisions between the Gault and Maestricht of Europe and also

pointed out the fact that Morton's uppermost division of the Cretaceous was really of Eocene age.

Philip T. Tyson in 1860, in his first report as State Agricultural Chemist, referred to the Cretaceous fossiliferous greensand of the Eastern Shore of Maryland and also mentioned the occurrence of the same formation to the south of Baltimore, although the latter observation was not substantiated by authentic paleontological data. He, furthermore, recognized the presence of some of the New Jersey Cretaceous divisions upon the Eastern Shore of Maryland but made little or no attempt at their delimitation.

For many years sugsequent to Tyson's work nothing of importance was accomplished in the interpretation of the Cretaceous deposits of Maryland. In 1889, however, the writer described the presence of fossiliferous Upper Cretaceous beds in Anne Arundel and Prince George's counties, Maryland, a number of highly fossiliferous localities being found at various points throughout this area. Many well-known Cretaceous fossils already described from the New Jersey formations were recognized and listed in this publication.

Subsequent to the publication of this article further investigations were carried on by the writer and his associates on the Cretaceous deposits of the state. At the same time a number of other students were engaged in a study of this and adjacent areas, among them P. R. Uhler and N. H. Darton, who proposed names for several of the formational units, Uhler proposing the names Baltimorean and Albirupean, the former representing the Potomac deposits described in the Maryland Geological Survey report on the Lower Cretaceous and the Albirupean portions of the nonmarine strata younger than the Potomac that are discussed in the present report. Darton proposed the name Magothy formation for the deposits overlying the Raritan, and the name Severn for the still later Cretaceous deposits of the state which the author of this chapter has correlated with the Matawan and Monmouth formations established in New Jersey and which contain quite distinctive faunas.

The relations of the Cretaceous deposits throughout the northern half of the Atlantic Coastal Plain, including Maryland, Delaware, and New

COMPARATIVE TAXONOMIC TABLE.

Lardner Vanuxem, 1829.	S. G. Morton, 1830.	S. G. Morton, 1834.	J. T. Ducatel, 1835.	J. C. Booth, 1841.
Secondary.	Ferruginous sand formation.	Middle. CRETACEOUS GROUP. Lower.	Green sand and Micaceous black sand.	Green sand. UPPER SECONDARY. Red clay.
Charles Lyell, 1843-5.	P. T. Tyson, 1860.	P. R. Uhler, 1872.	N. H. Darton, 1891-4.	Wm. B. Clark, 1894 et seq.
Cretaceous.	Cretaceous.	Cell marl. Loose marl. Mottled sands. Clay sand. Black marl. Alternate clay sands. Albirupean.	Severn. Magothy. Potomac (in part).	Monmouth. Matawan. Magothy. Raritan.

Jersey, were discussed by the writer in an article that appeared in the Bulletin of the Geological Society of America in 1894, and these conclusions are still further elaborated with the collaboration of his associates in the same publication in 1897. A later statement in which comparisons are also instituted with the South Atlantic and Gulf Upper Cretaceous is found in the Bulletin of the Geological Society of America for 1908 and in Professional Paper No. 71 of the U. S. Geological Survey for 1912.

In later years Edward W. Berry has made a very exhaustive study of the fossil plants of the Upper Cretaceous of the Atlantic Coastal Plain, and many brief contributions have been made by him on various phases of this subject. The results of these studies are incorporated in the extensive discussion which he has prepared for the present volume.

Still more recently Julia A. Gardner has been engaged in a study of the animal remains from the Upper Cretaceous beds of the state, and the results of her investigations are likewise published in the present volume.

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STRATIGRAPHIC AND PALEONTOLOGIC CHARACTERISTICS

The Upper Cretaceous deposits of Maryland extend from the Delaware border with gradually decreasing thicknesses to the valley of the Potomac River, where they finally disappear in surface outcrop by the transgression of the Tertiary deposits, which in Virginia rest directly on Lower Cretaceous strata.

The Upper Cretaceous deposits of Maryland are much less extensively developed than to the northward in New Jersey, where they attain their

greatest thickness in the northern Atlantic Coastal Plain and where they have been differentiated into a larger number of stratigraphic units than are recognizable in Maryland. The gradual transgression of the Tertiary deposits southward has also covered the uppermost formations of the New Jersey area which have not been recognized southwest of the Delaware line.

The Upper Cretaceous strata consist of sands, clays, and marls, the latter both calcareous and glauconitic. The marls, especially the greensand marls, are confined to the higher formations of the Upper Cretaceous and are most extensively developed in the Monmouth formation, where the beds are at times highly glauconitic. The strata are rarely consolidated, although indurated beds are found in the Raritan where they constitute the ledges at Rocky Point at the mouth of Back River, Baltimore County, and at the White Rocks, and on Stony and Rock creeks, Anne Arundel County. Indurated beds are also found in the Magothy formation on Magothy River, and less frequently in the Matawan and Monmouth formations, although here and there inconspicuous layers are developed in these formations both on the Eastern and Western shores.

The strata have in general a progressively lower dip to the southeastward in passing upward in the series, the dip varying from 30 feet to 35 feet in the mile in the lowest formation to not over 25 feet in the mile in the highest. The deposits apparently thicken slightly down the dip, although they probably thin farther to the seaward, as already discussed in the case of the Lower Cretaceous strata.

The stratigraphic relations do not indicate any marked unconformities beyond the gradual transgression of each succeeding formation over the preceding formation southward, although the Monmouth formation overlaps the Matawan entirely in central Prince George's County and overlies the Magothy formation directly for a considerable distance in this area. The materials comprising the several formations are, however, in the main more or less distinctive, and it is probable that considerable time intervals mark the stratigraphic breaks.

The Raritan and Magothy formations are of epicontinental origin, the marine waters nowhere reaching the area of recognized deposition in

Maryland in Raritan time, although possibly entering the region in the southern part of the district during the Magothy epoch as has been shown to be true in New Jersey in the vicinity of Cliffwood. The organic remains therefore of the Raritan and Magothy are chiefly of vegetable origin and represent a still further advance in development over the floras of the Patapsco formation of the Lower Cretaceous. With the opening of Matawan time the marine waters transgressed upon the land, and we find during the Matawan and Monmouth epochs a deposition of marine sediments containing an extensive fauna of Upper Cretaceous age.

The molluscan fauna of the Upper Cretaceous of Maryland includes 223 species, 129 pelecypods, 84 gastropods, 1 scaphopod and 9 cephalopods. These are segregated into 53 genera and 32 families of pelecypods, 38 genera and 26 families of gastropods, 1 genus and 1 family of scaphopods and 8 genera and 8 families of cephalopods.

All of the Upper Cretaceous horizons except the Raritan have yielded invertebrate fossils. The Magothy fauna, however, is very meager, consisting of 5 or possibly 6 species of bivalves and 1 univalve. Three out of the 6 or 7 species are restricted in their known distribution to the Magothy, 1 has not been recognized except from the Magothy and Matawan, 1 or possibly 2 range through the Magothy, Matawan and Monmouth and 1, the ubiquitous *Pecten quinquecostatus,* occurs at all horizons from the Magothy to the Rancocas.

The Matawan fauna is quite prolific, 75 or possibly as many as 83 species in all, including 48 to 53 pelecypods, 21 or 22 gastropods and 6 cephalopods. Approximately 57 per cent of these species are restricted to the Matawan. The restricted pelecypods are rather less than 50 per cent of the total, but 16 out of 22 of the gastropods and all of the cephalopods are peculiar. The strongest affinities of the fauna are with the Monmouth, 29 to 36 species, almost 43 per cent, being common to the two formations, while only 3 or possibly 4 species range downward and only 3, all of them bivalves, persist into the Rancocas. However, it is probable that if the Magothy and Rancosas formations were as well represented as the Matawan and Monmouth the number of common species would be greatly increased.

The Monmouth fauna is much the most prolific of any of the Upper Cretaceous faunas of Maryland; 158 or possibly 164 forms have been specifically determined, and there are a number of other species, most of them new, which have been disregarded because they are too poorly preserved to serve as types. Over 80 per cent of this fauna is peculiar. As in the Matawan fauna, the percentage of restricted pelecypods is much lower than that of either the gastropods or cephalopods; only a little more than 70 per cent of the Monmouth bivalves are peculiar to the horizon, while about 94 per cent of the univalves and all three of the cephalopods are restricted to that formation. Not more than 3 or possibly 4 of the 164 species run down into the Magothy, although about 22 per cent of the Monmouth forms occur in the Matawan. The Monmouth and Rancocas have only 5 species in common, 3 of the 5 being wide-ranging forms which are initiated before the opening of the Monmouth. The other 2 occur only in the Monmouth and Rancocas.

The Rancocas fauna is only imperfectly known. Gastropods undoubtedly are present, but none were found in a determinable state, so that all of the 8 species recorded are bivalves. Out of the 8, 3 are restricted in their known distribution to the Rancocas, 2 to the Monmouth and Rancocas, 2 to the Matawan, Monmouth and Rancocas, and 1 extends downward as far as the Magothy. *Gryphæa vomer* has not been reported from the Rancocas of Delaware, although it occurs at a similar horizon in New Jersey. It is the only Upper Cretaceous mollusk of Maryland which is known to survive the break between the Mesozoic and the Cenozoic.

From a biologic point of view the most interesting feature of the fauna is the relatively large number of Prionodesmacea, 75 out of the 129 bivalves, almost 53 per cent, being included in the most primitive of the three pelecypod orders. In the succeeding Eocene of Maryland only 24 out of 55, or 44 per cent, are referable to the Prionodesmacea, and in the Miocene of Maryland only 53 out of 187, or 28 per cent of the entire number.

A few of the genera represented, notably *Perissonota, Nemodon* and *Paranomia,* all of them described by Conrad from East Coast species, have not been recognized excepting from the Upper Cretaceous. *Inoce-*

ramus and *Exogyra,* though not restricted to the Cretaceous, are characteristic of it, while *Gryphæa* and *Trigonia* reach their culmination in the middle and upper Mesozoic. The Cretaceous representatives of the more highly specialized orders, the *Anomalodesmacea* and the *Teleodesmacea,* are conspicuously distinct from the later types. Of the four Anomalodesmacean genera, two of them, *Periplomya* and *Liopistha* are restricted to the Cretaceous; *Pholadomya* is distinctly Cretaceous in its affinities, though it persists in greatly diminished numbers even to the Recent, while *Cuspidaria* was likewise initiated in the mid-Mesozoic, and though wide-ranging has never been a major factor in any fauna.

The *Teleodesmacea,* the most highly organized order, is much less important, relatively, than in the Cenozoic faunas. The genera are more specialized than in the *Prionodesmacea,* and many of those identified in the fauna under discussion are either restricted to or characteristic of the Cretaceous. The sole representative of the *Cypricardiacea* is the abundant *Veniella,* a typically Cretaceous genus, although persistent into the Tertiary. The comparatively modern *Crassatellites* is the most abundant member of the Astartacean fauna, although *Crassatellina* and a number of undeterminable species of *Eriphyla,* both of them genera restricted to the Cretaceous, are also present. The *Carditacea* are represented by a single rare species of *Venericardia,* the *Lucinacea* by a rare *Myrtæa* and the Rancocas *Phacoides noxontownensis,* together with the prolific Cretaceous *Tenea* of rather uncertain affinities. *Cardium* is abundant during the late Mesozoic, as it is during the later Cenozoic. The Venerids are rather primitive; the prolific *Cyprimeria,* and *Legumen* do not survive the emergence at the close of the Mesozoic, while the more modern *Dosinia, Cyclina* and *Meretrix* are known from less than a dozen individuals. The prolific species of *Tellinacea* are all of them included under genera restricted in their distribution to the Cretaceous, *i. e., Tellinimera, Ænona* and *Linearia,* although the true *Tellina* is also present. Neither of the Solenacean genera, *Leptosolen* or *Solyma,* survives the close of the Mesozoic, nor does the prolific *Cymbophora,* the single representative of the *Mactracea.* Both of the *Myacea,* however, *Corbula* and *Panope,* are abundant in the Tertiary and Recent seas, as well as in the Cretaceous,

while all of the *Adesmacea, Martesia, Pholas* and *Teredo,* are initiated before the beginning of the Cretaceous and long survive its close.

The late Mesozoic affinities of the Gastropods are quite as obvious as those of the Pelecypods. *Avellana,* the Opisthobranch genus which is represented by the largest number of species, is restricted to the Cretaceous together with the closely allied *Cinulia. Acteon* and *Ringicula* were well established in the Mesozoic, although they are more closely identified with the Tertiary faunas. *Haminea, Acteocina* and *Cylichna* are all modern types which had a meager representation in the late Mesozoic. The Pleurotomids did not reach their culmination until the Tertiary, although they were no insignificant factor in the Upper Cretaceous faunas. The *Volutidæ* are a very highly specialized group and the genera referable to it are, for the most part, very restricted in stratigraphic distirbution. *Rostellites, Volutomorpha* and *Liopeplum* all were initiated in considerable numbers during the Upper Cretaceous, but none survived its close. The group of the *Fulguridæ, Fasciolariidæ,* and *Fusidæ* is represented by a number of highly specialized genera, prolific during the Upper Cretaceous but apparently restricted to it, notably *Pyropsis,* most closely allied to *Tudicla,* and *Serrifusus* of the *Fulguridæ, Piestochilus* and *Odontofusus* of the *Fasciolariidæ,* and *Pyrifusus* of the *Fusidæ. Pugnellus,* the single representative of the *Strombidæ,* is also restricted to the Cretaceous, while *Anchura* of the *Aporrhaidæ* occurs in the Jura as well. The *Cerithiidæ* and *Scalariidæ* occur but very rarely. *Laxispira,* the one genus of the *Vermitidae* which can be determined with assurance, has not been recognized excepting from the Cretaceous. Other members of the family probably occur, but it is difficult to separate them from the tubiculous worms. The *Turritellidæ* as represented by the type species are remarkably prolific in the Mesozoic as well as in the Cenozoic. *Pseudomelania,* the characteristic Mesozoic genus of the *Pyramidellidæ,* was rather more abundant during the early and mid-Mesozoic than near its close. The occurrence of the *Xenophoridæ* and the *Solariidæ* is insignificant. *Gyrodes,* the most abundant genus of the *Naticidæ* in the fauna under discussion, is restricted to the Upper Cretaceous, while *Lunatia* and *Amauropsis* have a much wider range. The *Trochidæ* are represented

by *Margarites* which was probably initiated before the opening of the Cretaceous and still persists. The ancient family of the *Euomphalidæ* includes a species which has been rather dubiously referred to *Discohelix*, a genus which is particularly characteristic of the Lias, although it has been reported from the Trias to the Oligocene. The occurrence of the single scaphopod is without significance.

Only *Eutrephoceras* among the cephalopods survived the close of the Mesozoic and that genus only into the Tertiary. All of the Ammonoids—*Pachydiscus, Baculites, Scaphites, Sphenodiscus, Placenticeras* and *Mortoniceras*—are restricted in their distribution to the Cretaceous, while the Dibranch *Belemnitella* has not been recognized excepting from the Upper Cretaceous.

THE RARITAN FORMATION

NAME AND SYNONYMY.—The Raritan formation, so named by the writer[1] from the Raritan River, New Jersey, in the basin of which it is typically developed, was later applied to deposits of the same age in Delaware and Maryland.[2] The term Plastic or Amboy Clays had hitherto been employed for this formation in New Jersey. Uhler included much of the Raritan in his Albirupean formation which, however, also embraced portions of the Patapsco and Patuxent formations in both Maryland and Virginia. McGee at the same time apparently included portions of the Raritan in his Potomac formation, although much of the Raritan both in Maryland as well as farther north was not included. Ward and other writers endeavored later to place all of the Raritan deposits in the Potomac group with which, however, they should not be combined either on stratigraphic or paleontologic grounds. The term Potomac group is therefore employed only for the Patuxent, Arundel, and Patapsco formations of Lower Cretaceous age.

AREAL DISTRIBUTION.—The Raritan formation extends across the state in a constantly narrowing belt from the Delaware line to the Potomac

[1] Clark, Wm. Bullock, Ann. Rept. of the State Geologist of New Jersey for the year 1892, pp. 181-186, 1893.

[2] Clark, Wm. Bullock, Bull. Geol. Soc. Amer., vol. vi, p. 480, 1894. Clark and Bibbins, Jour. Geol., vol. v, pp. 492-494, 1897.

FIG. 1.—VIEW OF GLASS SAND QUARRY NEAR STONY POINT, SHOWING RARITAN FORMATION UNCONFORMABLY OVERLAIN BY THE MAGOTHY FORMATION.

FIG. 2.—VIEW OF "CAPE SABLE" (NORTH FERRY POINT), MAGOTHY RIVER, SHOWING TYPE SECTION OF MAGOTHY FORMATION, LIGNITE BED WITH AMBER PELLETS AT BASE.

River. In Cecil County the width of outcrop attains a maximum of five to six miles along the dip, which is gradually reduced toward the southeast although expanding to some extent in northern Anne Arundel County until in central and southern Prince George's County it consists only of a narrow belt at times interrupted for considerable distances along the bluffs facing the Potomac River. The surface continuity of the formation is also interrupted by the waters of the Chesapeake Bay and the larger streams which flow across its outcrop. Outliers are found in the higher hills to the south and southwest of Elkton, and also in northern Anne Arundel and Prince George's counties where they occur at times several miles to the west of the main outcrop.

LITHOLOGIC CHARACTERS.—The Raritan formation consists largely of white or buff sands and white, pink, drab, or variegated clays, the strata changing rapidly in character both horizontally and vertically. The sands over wide areas form beds of nearly pure silicious grains and when dry are very white in color showing the presence of a very small percentage of hydroxide of iron. The white sands are more extensively developed in the upper part of the formation. The lower strata are generally much more highly colored and often indurated by the deposit of larger quantities of iron oxide which at times produces a characteristic tube-like structure, these deposits being known as "pipe ore." The indurated beds as already stated are well shown at Rocky Point near the mouth of Back River in Baltimore County as well as along the lower courses of Rocky and Stony creeks on the south side of the Patapsco River and at White Rocks in the immediate vicinity. It is the latter locality which afforded the name Albirupean employed by Uhler for the formation which he established to include these and other deposits. The upper, purer silicious beds have been extensively exploited as glass sands and large pits have been opened along the upper reaches of the Severn River.

Very coarse sands and even gravels are found at times well sorted but rarely with angular cobbles, in this respect differing from the Patuxent formation in which such materials not infrequently occur. At the same time the sands and gravels contain very little arkosic material which is so characteristic a feature of the Patuxent. The coarser sands and gravels

occur in irregular lenses at various horizons. These coarse beds are often so firmly cemented by hydroxide of iron that they have been employed locally for rough structural purposes. On Elk Neck rain pillars capped by indurated masses have been observed.

Sandy clays and clays occur as lenses at all horizons, the latter in very variable colors, at times white, but more frequently yellow, drab, or highly variegated, in this latter case being similar to the variegated clays of the Patapsco formation. Such clays are well exposed in the high bluffs at Worton Point, Kent County. The darker clays are at times lignitic and pyritic; and also contain small nodules of iron carbonate. The clays in places show thin partings of sand at regular or irregular intervals, which when near together give the clay a fissile character. At times isolated patches very rich in iron oxide are locally known as " Paint Pots," while the highly variegated layers of clay, also rich in iron oxide, have been referred to as " Peach Blossom Clays."

The deposits of the Raritan formation are in the main quite distinct from those of the underlying Patapsco formation, but are more nearly like those of the Magothy formation which, however, lacks the highly colored beds that are found here and there in the Raritan. At the same time the Magothy formation consists more largely of definitely stratified layers which betoken the beginning of the more distinctly open water stratification of the later Cretaceous formations.

STRIKE, DIP, AND THICKNESS.—The strike of the Raritan formation is in a general northeast-southwest direction, becoming nearly north and south in central and southern Prince George's County and in northern Charles County.

The dip of the beds is to the southeast and east at the rate of 30 feet to 35 feet in the mile, although it is somewhat greater in the outliers to the west of the main body of the outcrop nearer to the " fall-line."

The maximum thickness of the formation probably does not exceed 250 feet in the area of outcrop and generally is less than 200 feet, although this thickness is oftentimes not reached even in the northern part of the district where the chief development of the formation occurs. Farther south the thickness gradually declines until in Anne Arundel County it

is about 100 feet, which is further reduced to not over 50 feet in central Prince George's County, and with intermittent outcrops finally thins out by the overlapping of later formations in northern Charles County. The Raritan formation evidently thickens for a certain distance along the dip, as for example, in the deep well at Middletown, Delaware, where about 350 feet of materials are referred to this formation.

STRATIGRAPHIC AND STRUCTURAL RELATIONS.—The Raritan formation rests unconformably on the Patapsco formation, marked irregularities being found here and there along the line of contact indicating that rather pronounced inequalities existed on the upper surface of the Patapsco at the time of the deposition of Raritan strata. In general, the contact is sharply defined and at some points is marked by a line of broken and redeposited iron crusts.

The Raritan formation was eroded and transgressed toward the south by the Magothy formation. In southern Prince George's and Charles counties, however, the transgressing Eocene deposits overlie the Raritan beds, the strata being finally entirely overlapped in northern Charles County.

The internal stratigraphy and structure of the Raritan is complex oecause of the wide variability in the character of the materials, ranging as they do all the way from gravels and coarse sands to plastic clays. The rapid variation in the sands and clays both horizontally and vertically renders it impossible to subdivide the Raritan into members of more than very local importance.

The Raritan strata are evidently affected slightly along the western margin of the outcrop, particularly in the more distant outliers, by the warping of the beds which evidently occurs along the "fall-line" as shown by the marked difference in dip in the Lower Cretaceous formations in passing from the "fall-line" eastward. Local variations in dip also occur which suggest slight folding.

ORGANIC REMAINS.—The Raritan deposits have yielded both animal and plant remains. The fauna is very meager both in individuals and species, but the flora is much more abundant, particularly to the north

of Maryland, the strata of New Jersey having afforded numerous representatives of plants.

The animal remains known only in New Jersey consist of the bones of a plesiosaur and a few obscure mollusks of probably brackish-water habitat. Teredo borings have occasionally been found in lignitized coniferous wood. The fauna, however, does not afford sufficiently characteristic forms to be of any aid in determining the correlation of the deposits.

The flora of the Raritan formation embraces many types of plant life, including ferns, cycads, conifers, monocotyledons and dicotyledons. The most significant forms are the dicotyledonous plants which present a relatively modern aspect, a considerable advance being shown in this respect over the Patapsco flora. The silicified cycad trunks characteristic of the Patuxent formation have nowhere been observed. The fossil remains occur chiefly in the drab clays, the two localities furnishing the largest number of species in Maryland being located near the mouth of Back River and on Elk Neck, although much more highly fossiliferous localities have been found farther north in New Jersey. Among the characteristic species observed in Maryland are the following:

Asplenium dicksonianum Heer
Aralia washingtoniana Berry
Aspidiophyllum trilobatum Lesquereux
Araliopsoides cretacea (Lesquereux)
Araliopsoides breviloba Berry
Czekanowskia capillaris Newberry
Diospyros vera Berry
Fontainea grandifolia Newberry
Magnolia newberryi Berry
Platanus heerii Lesquereux
Protophyllum multinerve Lesquereux
Protophyllum sternbergii Lesquereux

The Raritan formation has been compared by Berry,[1] on the basis of the plant remains, with the Dakota sandstone of the Western Interior and with the Tuscaloosa formation of Alabama, which have a closely allied flora, although the Maryland beds are considered by him to be somewhat older. In terms of the European standard section the formation should unquestionably be placed in the Cenomanian.

[1] Berry, E. W., Jour. Geol., vol. xviii, p. 258, 1910.

THE MAGOTHY FORMATION

NAME AND SYNONYMY.—The Magothy formation, so named by Darton[1] from the Magothy River, Maryland, where the formation is typically developed, is now employed for the extension of these beds northward into Delaware and New Jersey. Uhler employed the name "Alternate Clay Sands" for portions of this formation, although he also included other deposits under this designation. The Magothy deposits have been for the most part included with the underlying strata, but there can be no question of their distinctness from the Raritan formation.

AREAL DISTRIBUTION.—The Magothy formation extends across the state from the Delaware line to central Prince George's County. The area of outcrop is much narrowed in Prince George's County until it ultimately comes to occupy a very narrow belt to the east of the Raritan formation. In Cecil, Kent, and Anne Arundel counties its outcrop varies from two to three miles in width which is somewhat exceeded if the outliers on Elk Neck, Cecil County, and in northern Anne Arundel are included. The continuity of the outcrops is very materially interfered with by the Chesapeake Bay and several of the larger tidal streams, among them Elk, Bohemia, Sassafras, Magothy, and Severn rivers.

LITHOLOGIC CHARACTERS.—The Magothy formation is largely made up of light-colored sands, at times coarse and conglomeratic. Some of the beds are in places consolidated to form a brown sandstone, and the sands themselves are at times highly colored by the admixture of hydroxide of iron. Clays, generally drab or chocolate brown in color, also occur, although the clay beds are subordinate to the sand beds in this formation. The dark colored beds are often highly lignitic and at times pyritic. The lignitic material is generally very finely divided, but it may occur in larger masses.

The deposits change rapidly in character both horizontally and vertically and in this respect are not unlike the Raritan deposits. Cross-bedding likewise occurs, but is on the whole less prominent than in the earlier formation. At some of the localities the beds present a very

[1] Darton, N. H., Amer. Jour. Sci. 2d ser., vol. xlv, pp. 407-419, 1893.

marked and pronounced stratified character, especially in some of the clays which are finely laminated. A striking feature of these deposits is the presence of amber which was described from beds of this age at "Cape Sable" (North Ferry Point), Magothy River, by Troost in 1821. The amber occurs in layers of lignitic sandy clay in the form of pellets.

The light-colored white sands contain pinkish angular quartz grains, and at times much muscovite. A characteristic type of stratification is seen in the sandy layers separated by thin laminæ of dark-colored clay or sandy clay which is often leaf-bearing. It was due to the frequency of this laminated structure that Uhler was led to propose the name "Alternate Clay Sands" for these beds. Such clay laminæ at Grove Point and other localities have furnished an extensive flora.

The Magothy deposits, particularly at "Cape Sable" (North Ferry Point) on the Magothy River, afforded in earlier days not inconsiderable outputs of alum and copperas, derived from the lignitic and pyritic beds. The "Baltimore Alum and Copperas Works," at Locust Point, Baltimore, produced large quantities of these products which Ducatel estimated in 1834 as amounting to over $80,000 annually.

The Magothy formation lacks the massive beds of highly colored clays found in the Raritan, while the variable and rapidly alternating sands and clays are infrequent in the latter. The materials of the Magothy are also for the most part readily distinguished from the overlying Matawan by the absence of glauconite in the former and by the lack of homogeneity which is so marked a feature of the Matawan deposits.

STRIKE, DIP AND THICKNESS.—The strike of the Magothy formation is essentially like that of the Raritan formation. It has a general northeast-southwest direction throughout much of the area of outcrop, except in Prince George's County where it is more nearly north and south.

The dip of the beds is to the southeast and east and at the rate of about 30 feet to the mile, although this is somewhat increased in the case of the outliers to the west of the main body of the outcrop.

The Magothy formation has a maximum thickness at times of nearly 100 feet in the northern part of the district, but even here the thickness is variable and in some places does not exceed one-half that amount.

Farther south in Anne Arundel County it has been estimated to have a maximum thickness of about 60 feet on the Magothy River, which declines to about 30 feet on the Severn River, and in central Prince George's County it rarely reaches more than 10 to 15 feet.

STRATIGRAPHIC AND STRUCTURAL RELATIONS.—The Magothy formation overlies the Raritan unconformably and gradually transgresses that formation southward, although it does not entirely overlap it along the line of outcrop. The contact at times is not very sharply defined on account of the unconsolidated character of the materials, but a broad study of the relations indicates the unconformable nature of the contact.

The Matawan formation also overlies the Magothy formation unconformably and likewise transgresses it southward, although over much of Prince George's County the transgression by still later formations makes it impossible to determine the extent of this overlap to the southward. The stratigraphy and structure of the Magothy beds is complex and, as in the case of the Raritan formation, the wide variability in the character of the materials renders it impossible to subdivide the Magothy into members of more than local importance.

The relatively limited area of outcrop of the Magothy formation has afforded little if any evidence of warping, although the slightly greater dip in the more western outliers as compared with the main body of the formation suggests that there may have been some deformation along the "fall-line."

ORGANIC REMAINS.—The Magothy formation has afforded both animal and plant fossils. The animal remains, chiefly marine mollusks, are confined to a few localities in the extreme northern and southern portions of its outcrop. The locality at Cliffwood, New Jersey, has long been known and has afforded a considerable marine fauna, while a similar occurrence on Good Hope Hill, District of Columbia, near the southern extremity of the occurrence of the Magothy has likewise afforded a number of similar forms.

The Magothy fauna in Maryland is unfortunately known from but a single locality, Good Hope Hill, near Anacostia, D. C. By far the most abundant species, a small *Corbula,* suggesting the *C. bisulcata* of

Conrad, occurs in so poor a state of preservation that it has not been described. Another very conspicuous element in the fauna is a *Panope* which is, like *Corbula,* a muddy bottom form. *Turritella* is also abundant and *Pecten* and *Cardium* fairly common, while *Tenea* and *Solyma* have a limited representation.

The fauna, meager as it is, very clearly indicates muddy bottom conditions, probably estuarine in character and quite possibly at the mouth of the ancient Potomac.

The flora of the Magothy formation has afforded numerous types of plant life including ferns, cycads, conifers, and dicotyledons that present many points of difference from the Raritan flora, and are of more modern aspect. Among the more important fossiliferous localities that have afforded plant remains may be mentioned "Cape Sable" (North Ferry Point) on the Magothy River, and Grove Point at the mouth of the Sassafras River. Among the characteristic species found in the Magothy of Maryland are:

Aralia ravniana Heer
Araucaria marylandica Berry
Asplenium cecilensis Berry
Bauhinia marylandica Berry
Bumelia prænuntia Berry
Carex clarkii Berry
Coccolobites cretaceus Berry
Colutea obovata Berry
Cornus forchhammeri Heer
Dalbergia severnensis Berry
Dammara cliffwoodensis Hollick
Elæodendron marylandicum Berry
Eucalyptus wardiana Berry
Ficus crassipes Heer
Gleichenia saundersii Berry
Hedera cecilensis Berry
Lycopodium cretaceum Berry
Magnolia capellinii Heer
Moriconia americana Berry
Nelumbo kempii Hollick
Protophyllocladus lobatus Berry
Sabalites magothiensis Berry
Sapotacites knowltoni Berry
Sterculia cliffwoodensis Berry
Sterculia minima Berry
Widdringtonites reichii (Ettingshausen) Heer

FIG. 1.—VIEW OF ROUND BAY, SEVERN RIVER, SHOWING MAGOTHY FORMATION OVERLAIN BY MATAWAN FORMATION.

FIG. 2.—NEARER VIEW OF SAME, SHOWING CONTACT BETWEEN THE MAGOTHY AND MATAWAN FORMATIONS.

The Magothy formation is evidently equivalent to the lower part of the Black Creek formation of North Carolina, which also embraces in its upper part the Matawan formation as well. In the Black Creek formation the beds containing the typical Magothy flora and strata bearing the marine Matawan fauna are found interstratified. The Magothy has also been correlated with the Tuscaloosa deposits of western Alabama, although the latter is likewise the equivalent in part of the Matawan. The Magothy formation is referred to the Turonian in the European scale.

THE MATAWAN FORMATION

NAME AND SYNONYMY.—The Matawan formation, so named by the writer[1] from Matawan Creek, New Jersey, where deposits of this age are extensively developed, is also applied to the extension of these strata into Maryland. The term Clay Marls was long used for these deposits in New Jersey. Darton described under the name of the Severn formation in the Maryland area both the Matawan and Monmouth formations. Uhler proposed a number of lithologic units, the stratigraphic relations of which are undeterminable, for these deposits. The writer divided the Matawan formation in New Jersey, from below upward, into the Crosswicks clays and Hazlet sands, and the New Jersey geologists have still further divided the Crosswicks clays into the Merchantville clay and the Woodbury clay, and the Hazlet sands into the Englishtown sand, the Marshalltown formation, and Wenona sand, the term Matawan being retained as a group term to include these five formations in New Jersey. It has been impossible, however, to satisfactorily recognize these subdivisions of the Matawan to the south of the Delaware basin.

AREAL DISTRIBUTION.—The Matawan formation has been traced from the Delaware line across Cecil and Kent counties to the shore of the Chesapeake, beyond which it is again found outcropping in Anne Arundel and northern Prince George's counties, beyond which it is overlapped by later formations. The width of outcrop on the Eastern Shore is

[1] Clark, Wm. Bullock, Jour. Geol., vol. ii, pp. 163, 164, 1894; Bull. Geol. Soc. Amer., vol. vi, p. 481, 1894.

about two miles. In the interstream portions of Anne Arundel County it extends from water level to the higher points of the region, and although of less thickness it covers a wider area from northwest to southeast on account of the more elevated character of the country. Beyond the Patuxent River the outcrop gradually narrows until it disappears entirely before the center of Prince George's County is reached. A few outliers are found on Elk Neck in Cecil County and at a few points in Anne Arundel County.

LITHOLOGIC CHARACTERS.—The Matawan formation consists largely of dark-colored micaceous sandy clays, often glauconitic. At times the deposits become very sandy and lighter-colored, while at other times they form a black clay. The upper part of the formation is generally predominantly arenaceous, the sands varying in color from almost white to a dark greenish black. The beds in general are very persistent in character, and the rapid change of materials so common in the Raritan and Magothy formations does not occur. A thin pebble bed at times marks the base of the formation. Iron pyrites has been found at times in the darker and more carbonaceous beds.

The glauconitic constituent of the beds is much less pronounced than in the overlying Monmouth formation, although glauconite grains are not uncommon. The decomposition of the glauconite in the weathered beds produces reddish-brown materials that are at times indurated by the hydrous iron oxide, producing thin ledges or crusts on exposed surfaces. The deposits of the Matawan formation are quite unlike those of the underlying Magothy and show by their pronounced stratification the distinctly marine conditions which prevailed during their deposition. The homogeneous nature of the material over extended areas is in marked contrast to the alternating sands and clays that are found so extensively in the Magothy. The materials of the Matawan are on the whole much more like the succeeding Monmouth formation, but the latter is more arenaceous and glauconitic, and the dark-colored micaceous sandy clays and black clays of the Matawan are rarely found. The Matawan deposits, especially in Anne Arundel County, frequently contain large oval concretions of clay ironstone which are very characteristic.

STRIKE, DIP, AND THICKNESS.—The strike of the Matawan formation is in general similar to that of the underlying Magothy formation and continues in a northeast-southwest direction from the Delaware line to northern Prince George's County. The dip of the beds is to the southeast and east at the rate of about 25 feet in the mile. The thickness of the formation in Cecil and Kent counties reaches a maximum of about 70 feet. To the southward it declines gradually in thickness until it reaches an average of about 50 feet in Anne Arundel County. Toward the Patuxent River it gradually thins and finally disappears a few miles to the southwestward, in northern Prince George's County.

STRATIGRAPHIC AND STRUCTURAL RELATIONS.—The Matawan formation rests unconformably on the Magothy formation. No marked irregularities occur, but the Matawan formation gradually transgresses the Magothy to the southward as already pointed out.

The Matawan formation is also unconformably overlain by the Monmouth formation. Although no marked irregularities of contact have been observed, the Monmouth formation transgresses the Matawan formation to the southward where it finally overlaps it altogether and comes to rest on the Magothy formation.

The internal stratigraphy and structure of the Matawan is very simple because of the slight variability in the character of the materials over wide areas. The somewhat more arenaceous character of the upper beds is not sufficiently marked, however, to justify the separation of the Matawan into independent members, especially as no faunal differences are recognizable either in Maryland or to the northward in New Jersey.

ORGANIC REMAINS.—The Matawan deposits in Maryland have furnished only animal remains, with the exception of a single cone scale of *Dammara* from Millersville, Anne Arundel County. The animal remains are entirely of marine types and probably lived under conditions of moderate depth, such as are found well within the 100-fathom line. Among the groups represented are *Echinodermata, Vermes, Bryozoa, Crustacea, Pelecypoda, Gastropoda, Cephalopoda,* and *Pisces.* The fossils have been found chiefly in the dark-colored sandy clays.

The Matawan is represented in Maryland and Delaware in two distinct areas, the one along the Chesapeake and Delaware Canal, Delaware, and the other in Anne Arundel County, Maryland.

The fauna of the Delaware area is much less homogeneous in character than that of Maryland, and some of the faunal zones which Weller differentiated in New Jersey apparently persist to the southwest, though much less sharply defined than at the type localities. In general, the fauna becomes increasingly younger to the eastward. The presence of *Exogyra costata* near Delaware City and of *Belemnitella* at Briar Point indicates that there is probably some Monmouth from the canal dump mingled with the Matawan at these localities. In the immediate vicinity of Summit Bridge and at Post 105 a fauna is represented analogous to that of the Merchantville and Woodbury of New Jersey. Among the most characteristic species in the fauna of approximately twenty species are *Anchura rostrata, Turritella delmar, Laxispira lumbricalis, Liopistha alternata, Mortoniceras delawarensis, Placenticeras placenta,* and *Scaphites hippocrepis. Turritella delmar,* which is one of the most abundant species, was described from Delaware and has been reported only from the environs of the type locality. *Laxispira lumbricalis, Anchura rostrata, Placenticeras placenta,* and *Scaphites hippocrepis* are characteristic Merchantville forms, while *Mortoniceras delawarensis* and *Liopistha alternata* are peculiar not only to the Merchantville but to the *Mortoniceras subzone* of the entire eastern United States and Gulf. Because of the presence of this characteristic genus the horizon has been called by the name of the *Mortoniceras subzone* rather than the more local term "Merchantville." Furthermore, the Summit Bridge fauna is probably the equivalent not of the Merchantville alone but of both the Merchantville and the Woodbury. Even within the limits of New Jersey Weller noticed that the differentiation between them became increasingly difficult toward the south, and in Delaware it is apparently obliterated. Both typical Merchantville forms, such as *Mortoniceras delawarensis,* and typical Woodbury forms such as *Yoldia longifrons,* occur at a single locality, although the earlier types are dominant.

The Mortoniceras fauna is a relatively deep-water fauna and notable for the absence of the Ostreids. In this respect it stands in marked contrast to the fauna which is most typically developed to the eastward in the vicinity of Camp Fox, opposite Post 236, on the Chesapeake and Delaware Canal. By far the most conspicuous element in the latter, from the point of view of both numbers and size, is the Ostreids. At certain localities, notably at Camp Fox, the beach is paved and the side of the Canal heavily studded with *Gryphæa vesicularis*. *Exogyra cancellata*, which occurs near the top of the *E. ponderosa zone* and the base of the *E. costata zone*, is ubiquitous throughout the restricted area in question but less prolific than *G. vesicularis*. *Ostrea falcata* is also a characteristic form, though less conspicuous by reason of its smaller size. A number of species of the smaller bivalves and univalves occur but none of them is abundant, while the cephalopods are very rare. The general aspect of the fauna is very similar to that of the Marshalltown of New Jersey which, like the fauna west of St. Georges, is best characterized by the abundance of the ponderous Ostreids.

The Matawan fauna from the Magothy River in northern Anne Arundel County is very meager, but is more homogeneous in general character and is less readily separable into faunules than is that along the canal. The fauna includes a few characteristic Merchantville types, such as *Schaphites hippocrepis*, but it also includes a number of the forms restricted in New Jersey to the Upper Matawan and a few southern species which characterize the *Exogyra ponderosa zone*, such as *Cucullæa carolinensis*, which has not been recorded from the Cretaceous farther north. The fauna, on the whole, is more cosmopolitan than any occurring to the northward and was probably laid down in a more open sea which was more accessible from the south.

The Matawan formation is the equivalent of the upper part of the Black Creek formation of North Carolina and is also represented in the Eutaw formation, and probably the lower part of the Ripley formation and its equivalent the Selma chalk of the eastern Gulf region. The forms point to the Turonian age of the beds.

THE MONMOUTH FORMATION

NAME AND SYNONYMY.—The Monmouth formation was so named by the writer[1] from Monmouth County, New Jersey, where the deposits of this formation are characteristically developed. These deposits were formerly known in New Jersey under the name of the Lower Marl Bed and the Red Sand. Darton considered the Monmouth formation as the upper part of his Severn formation. Uhler discussed these deposits under lithologic names which cannot be readily recognized. The present writer divided the New Jersey Monmouth formation into the Mt. Laurel sands, the Navesink marls, and the Redbank sands and these have been more recently employed as formational units by the New Jersey geologists. These subdivisions cannot be recognized in Maryland.

AREAL DISTRIBUTION.—The Monmouth formation extends from the Delaware boundary to southern Prince George's County, a few miles to the south of Washington. The width of outcrop is variable, reaching 4 or 5 miles in maximum extent in Cecil County, but rapidly narrowing in Kent County, where it is reduced to about 2 miles in width. In Anne Arundel and Prince George's counties it occupies a very irregular line of outcrop due to the higher country, the strata being traced from the hilltops in the northwest down the valley lines to their disappearance at tide level, and therefore often reaching a total width of outcrop in the stream channels along the dip of 4 to 5 miles. Farther to the southwestward in Prince George's County the Monmouth forms a narrow band which finally disappears by the overlap of later formations.

LITHOLOGIC CHARACTERS.—The Monmouth formation consists chiefly of reddish and pinkish sands, generally glauconitic, the beds in places forming a dark greensand. The glauconitic feature is much more marked than in the preceding Matawan. When unweathered the glauconitic beds are dark green or nearly black in color, but become reddish-brown when weathering.

The deposits are commonly loose and unconsolidated, but are locally indurated by the ferruginous cement derived from the weathering of the

[1] Clark, Wm. Bullock, Bull. Geol. Soc. Amer., vol. viii, pp. 331-336, 1897.

glauconite. In some places iron crusts of irregular shape are found, but the indurated materials more often occur in the form of layers one or two inches in thickness. At other times tubular or rounded concretions occur which are filled with gray sand in which grains of unweathered glauconite are present.

The beds are very homogeneous over wide areas and in this respect are not unlike the deposits of the Matawan, although they are more arenaceous and glauconitic. The alternating clays so common in the Matawan are absent, and clay deposits generally are unfrequent. Because of the similarity of the materials the Monmouth is, when unfossiliferous, distinguished with difficulty from the overlying Eocene Aquia formation, although the broader relations show that a marked interval separated the two.

STRIKE, DIP, AND THICKNESS.—The Monmouth formation has the same general strike as the underlying formations, maintaining a nearly northeast-southwest direction from eastern Cecil County to central Prince George's County. The dip of the beds is to the southeast at the rate of 20 to 25 feet in the mile. The maximum thickness of the formation on the northern Eastern Shore is about 100 feet. Along the Sassafras River it is reduced to about 65 feet, and in Anne Arundel County to about 50 feet. It generally declines from this area southward until in central Prince George's County it is only 20 to 25 feet in thickness, beyond which it gradually thins out, due to the overlap of later formations.

STRATIGRAPHIC AND STRUCTURAL RELATIONS.—The Monmouth formation overlies the Matawan formation unconformably, although no marked irregularities of surface have been observed in the region. The Monmouth formation gradually transgresses the Matawan formation to the southward until it comes to rest on the Magothy formation. It is the most conspicuous transgression observed in the Upper Cretaceous section.

The Monmouth formation is overlain unconformably by Tertiary deposits both of Eocene and Miocene age, since the southwardly-transgressing Aquia formation is in turn overlapped by the Calvert formation so that both are at times found in contact with the Monmouth strata.

The Monmouth formation presents very simple problems in stratigraphy and structure since the deposits are remarkably homogeneous over extensive areas. No marked change in strike and dip are observable, while no folding of the strata can be detected. No segregation of the formation into members of more than very local extent has been possible.

ORGANIC REMAINS.—The fossils of the Monmouth formation in Maryland are entirely animal remains of marine type and evidently lived on the continental shelf within the 100-fathom line. The more glauconitic character of the beds and their more homogeneous structure suggest that the habitat of these forms may have been slightly deeper than that of the Matawan fauna, since the conditions of formation of glauconite point to areas of slight deposition of terrigenous materials. The groups of animal remains represented comprise the corals, echinoderms, vermes, bryozoa, crustacea, pelecypods, gastropods, and cephalopods. The fossils occur chiefly in the dark-colored glauconitic beds, where at a few localities great numbers have been collected in a splendid state of preservation.

The Monmouth fauna is very much larger than the Matawan, much better preserved and much more cosmopolitan in its affinities. Out of a total of 158 or possibly 164 species listed, 35 per cent are new. This high percentage of new forms by no means indicates a local fauna, but rather a very large one which is only imperfectly known.

There are three areas of distribution in Maryland, one on the Eastern Shore in Cecil County, another along the Sassafras River in Cecil and Kent counties, the third in Prince George's and Anne Arundel counties.

The Sassafras River fauna though prolific is very poorly preserved, and the determinable species are none of them diagnostic of any particular facies. The most striking difference between the Monmouth of Cecil County as developed along the Bohemia Creek and that of Prince George's County is the cephalopod element. The latter is represented on the Eastern Shore by *Belemnitella,* on the Western Shore by *Sphenodiscus lobatus* and less commonly by *Scaphites conradi.* This suggests an affinity of the former with the Mt. Laurel-Navesink marls, the horizon in which *Belemnitella* is exceedingly abundant and to which it is restricted. *Sphenodiscus,* on the other hand, in New Jersey is the most

FIG. 1.—VIEW OF LOWER WHITE BANK, ELK NECK, SHOWING PATAPSCO, RARITAN, AND MAGOTHY FORMATIONS.

FIG. 2.—VIEW OF GROVE POINT SHOWING MAGOTHY FORMATION OVERLAIN BY MATAWAN FORMATION.

characteristic species of the Tinton and is confined to it. The abundant presence of this form in Prince George's County cannot but suggest a synchroneity with the New Jersey Tinton. It is difficult to explain the absence of *Belemnitella* by any other than a stratigraphic difference, since the conditions were apparently quite as favorable for its existence in the later Monmouth as they were in the earlier. In the European Mesozoic the Belemnitellas are considered among the most valuable of the guide fossils since they originated abruptly, dispersed rapidly and became extinct in as short a time as that required for their initiation. It is equally difficult, however, to explain the absence of *B. americana* by its early extinction, since its supposed European equivalent, *Belemnitella mucronata,* is restricted to the upper portion of the uppermost Senonian, a horizon higher than that generally accepted for the Navesink. Aside from the presence of *Belemnitella,* the Bohemia Creek fauna is notable for the relatively large number of Ostreids, a feature which it shows in common with the later Matawan and the Navesink of New Jersey. It differs from the Navesink, however, in the absence of a large gastropod fauna. Apparently the waters were even more shallow in the area inhabited by the *Belemnitella* fauna than in that characterized by the presence of *Sphenodiscus* and by the relatively few Ostreids, particularly those of the more ponderous type. The *Sphenodiscus* fauna is restricted in its known distribution in Maryland to the Western Shore, and, indeed, to Prince George's County. These marls have furnished the most prolific of any of the Upper Cretaceous faunas of Maryland. The fossils are in an excellent state of preservation, though very soft and prone to crumble. The characteristic elements of the fauna, aside from the widespread *Sphenodiscus,* are *Nucula slackiana, Cucullæa vulgaris,* a number of small oysters, *Exogyra costata* in limited numbers, *Trigonia eufalensis,* a number of *Pecten,* notably *simplicius* and *argillensis, Crenella serica, Liopistha protexta, Crassatellites vadosa,* several *Cardia,* the prolific *Cyprimeria major,* two new species of *Cymbophora,* and a large number of *Corbulæ, Pleurotomidæ, Volutes, Pyrifusi* and *Naticidæ,* together with *Turritellæ* in great abundance. The absence of Brachiopods and Scaphopods is rather remarkable.

The general make-up of the fauna indicates a muddy bottom covered by quiet waters, certainly not more than 50 fathoms in depth. However, it is by no means an estuarine fauna but one that lived in the open sea. There was, probably, free communication with the inshore life of the Gulf region, but there may have been a barrier, possibly a volume of fresh water, which shut off some of the New Jersey shore life. The waters were doubtless warmer and much more uniform in temperature, and environmental conditions, as a whole, more favorable to molluscan life than they are off the Maryland coast to-day.

The Monmouth formation is the equivalent of the Peedee beds of North and South Carolina and the upper part of the Ripley and its equivalent, the Selma chalk of the Gulf. The forms point to the Lower Senonian (Emscherian) age of the beds.

THE RANCOCAS FORMATION

The Rancocas formation, so named by the writer[1] from Rancocas Creek, New Jersey, where the deposits of this horizon are extensively developed, has not been found to outcrop within the limits of the state, although it occurs in Delaware near the Maryland Line and in all probability occurs in Maryland beneath the cover of the Tertiary formations. Its separation from the underlying deposits under the name of the Middle Marl in New Jersey was early recognized. The subdivisions of this formation into the Hornerstown marl and Vincentown sand in New Jersey become gradually obscured to the southward, the marl even appearing within or at the top of the lime sands.

The Rancocas formation overlies the Monmouth unconformably and its line of contact is generally sharply defined.

It contains a fauna very distinct from those of the underlying Upper Cretaceous formations. The faunas of the Magothy, Matawan, and Monmouth are much more closely allied with one another than with the Rancocas formation in which quite distinct faunal elements make their appearance. No deposits of equivalent age have been recognized in the

[1] Clark, Wm. Bullock, Jour. Geol., vol. ii, p. 166, 1894.

south Atlantic and Gulf states, although the characteristic Rancocas species, *Terebratula harlani*, has been questionably determined in materials obtained from the deep-well borings at Old Point Comfort, Virginia. The Rancocas fauna points to the Danian age of this formation.

The Rancocas fauna has not been discovered in Maryland, although it is quite well represented in Delaware in the vicinity of Odessa. The diagnostic features of the fauna are essentially those of the Vincentown of New Jersey—a prolific bryozoan fauna, *Terebratula harlani* in abundance, and a very meager molluscan representation. The mollusca of the two areas are curiously dissimilar, none of the few characteristic species of New Jersey, *Cardium knappi, Carvatis veta, Polorthis tibialis,* occurring in Delaware, while the abundant *Gryphæa,* to which the characteristic Vincentown bryozoa attach themselves, is apparently not present in New Jersey. It is probable that the Delaware Rancocas represents a fossil oyster bank where the ensemble of the life was, as it is to-day, very distinct from the fauna a short distance removed from the bank.

In the coarse greensands in the vicinity of Noxontown Pond a very prolific fauna occurs, but in such a wretched state of preservation that but little attempt has been made to give it a place in the literature. No trace of *Terebratula harlani* could be detected, nor are any of the diagnostic species of the Rancocas recognized. It is, apparently, a very much localized inshore assemblage, the two most prolific constituent species being an undescribed *Yoldia* and an undescribed *Phacoides*.

LOCAL SECTIONS

I. Section at "Red Hill," along the west slope of Gray's Hill, Cecil County, beginning at 200 feet above tide.

		Feet.
Cretaceous.		
Raritan	Coarse reddish sand and evenly-bedded dark brown sandstone ledge	10
	Yellow and buff sand and corrugated iron stone	10
	Tough white clay reddish in places	7
Patapsco	Massive variegated red and drab clay, the latter slightly lignitic and containing obscure leaf impressions. Lenses of white, water-bearing sand near base.	130
Patuxent	Sand, not exposed at surface, to tide level	43
	Total	200

II. Shannon Hill near Northeast, Cecil County.

		Feet.
Pleistocene or Recent	Loam and red clay	5-10
Cretaceous.		
Raritan	Dense plastic chocolate colored clay with flakes of iron carbonate carrying leaf impressions	10
Patapsco	Light colored sand	8
	Sandy chocolate colored clay	10
	Drab and light colored clay and sand grading into next member	8
	Chocolate clay, slightly lignitic	7
	Variegated clay	18
	White sand	1
	Variegated clay	35
	Yellow and purple sand and ferruginous sandstone	5
	Total	112

III. Section of Well at Fort Dupont, Newcastle County, Delaware.

		Feet.
Pleistocene.		
Talbot	Yellowish sand and fine gravel, brackish water	0–24
Cretaceous.		
Rancocas	Gray, slightly clayey sand and fine gravel	24–40
	Dark greenish, limy sand with shells, contains much glauconite	40–60
Monmouth	Dark sandy micaceous clay	60–140
	Medium gray sand with very little glauconite	140–160
	Brownish gray sandy clay with some glauconite	160–180
Matawan	Dark coarse sand and clay, some glauconite	180–197
	Hard, light red, slightly sandy clay	197–223
	Dark, micaceous, sandy clay	223–240
	Fine to medium drab or brownish gray, clayey sand with a little glauconite	240–280
	Fine to coarse brownish, micaceous clay with some glauconite	280–300
Magothy	Medium to coarse drab or brownish sand with varying amounts of glauconite and occasionally some clay	300–418
	Fine to medium, light gray sand, no clay and very little glauconite	418–421

		Feet.
Cretaceous.		
Raritan....	Light, brick-red clay with some sand............	421–467
	Pink to medium, slightly clayey, pinkish buff or pinkish brown sand..........................	467–500
	Fine to medium brownish gray micaceous sand...	500–510
	Medium to fine pinkish brown sand with red and white clay	510–640
	Fine to medium light brown micaceous sand and clay	640–650
	Brownish gray, micaceous, clayey sand containing lignite	650–661
Patapsco...	Fine to medium pinkish brown sand with beds of pink, red and white clay and lignite............	661–710
	Medium varicolored sand with lignite............	710–725
	Coarse, light pinkish brown sand................	725–730
	Light brown sand containing many brown granules, also lignite	730–734
	Dark, brownish clay and coarse sand............	734–736
	Medium, pinkish brown, clayey sand..............	736–740
	Brown clay with coarse sand, contains lignite.....	740–745
	Medium, brownish, clayey sand..................	745–750
	Fine to coarse pinkish brown sandy clay containing brown granules and lignite....................	750–755
	Medium, grayish brownish clayey sand...........	755–762

IV. Section west side of Maulden Mountain (Lower White Banks), Elk Neck.

		Feet.
Recent..........	Wash material	6–8
Cretaceous.		
Magothy...	Laminated white sand alternating with white clay (lense of pink sand at the top)................	20
	Irregular ledges of ironstone....................	4½
	Cross-bedded pink or yellow loose sands with some iron crusts (full of bank-swallows' holes).......	6–8
	White clay	2–3
	Ironstone ledges	2½–3
	Fine quartz pebbles with some pellets of white clay.	1½–3
Raritan....	Cross-bedded yellow sand passing into a pink sand with occasional thin lenses of ironstone.........	10
	Gray to buff sand.............................	12
	Ledge of ironstone............................	1–3
	Cross-bedded brown and yellow, often indurated sand	12½
	Alternating white clay with pellets of red iron oxide and buff to white finely laminated sand with white clay pellets and occasional ledges of ironstone...	16
	Cross-bedded yellow sand with irregular ironstone layers, sometimes forming massive ledges.......	7–8
	Mottled pink and white clay passing gradually into next member	7
	Laminated white sandy clay, in places passing into an ash-colored sand..........................	22
	Fine white sand with pellets and lenses of clay....	23½
Patapsco...	Dark drab clay containing lignite, white clay at the top and sometimes brown clay below...........	10
	Total	168½

V. Section southwest side Maulden Mountain (Gillers Hole), Elk Neck.

		Feet.
Pleistocene.		
Lafayette	Clay loam	8–10
	Pebble conglomerate and loose pebbles	1½–2
Cretaceous.		
Matawan	Fine greenish gray sand with finely disseminated glauconite	5½
	More grayish glauconitic sand, quite micaceous with small pockets of glauconite and some iron concretions	15
	Persistent layer of ironstone	
	Gray iron mottled sand less glauconitic, micaceous	10
Magothy	Very fine ash-colored micaceous sand with thin lenses and small pellets of white and yellow clay and pellets of coarse yellow sand, the whole becoming argillaceous toward the base	9
	Mottled yellow and white arenaceous clay with small iron carbonate concretions, passing insensibly into next member	10
	Finely laminated yellow, gray, salmon and white cross-bedded fine sand with iron concretions and numerous pellets and lenses of clay in places	6
	Drab sandy micaceous clay with comminuted lignite	5½
	Layer of loose, small white quartz pebbles	½
Raritan	Mottled yellow and white (some blotches of red) clay	11
	Ironstone band	
	Fine white sand with some layers of slightly indurated yellow sand	13
	Buff sand of same character, centrally dark and lighter above and below	11
	Similar white sand	4
	Yellow sand with clay pellets, firmly indurated in places	4
	Cross-bedded yellow, buff and pink sand	5
	Red and yellow sands with ledges of ironstone and in places with loose gravel of angular quartz pebbles	10
	Finely laminated somewhat sandy white plastic clay	5
	Talus covered slope	25
	Loose yellow sand with pink blotches alternating with white clay. The sand indurated in places and containing ironstone	27
Patapsco	Compact drab clay with lignite, to tide	8
	Total	195½

VI. Section south side of Chesapeake and Delaware Canal 1 mile east of Pivot Bridge, between Mileposts 67 and 68.

		Feet.
Pleistocene.		
Talbot	Somewhat disturbed brownish-yellow to gray sandy loam with bands of pebbles and cobbles at base	8
Cretaceous.		
Matawan	Dark greenish-black micaceous glauconitic sand with small pockets consisting almost entirely of glauconite decidedly green in color. Thin discontinuous band of small subangular quartz pebbles at base	3
	Irregular contact.	

		Feet.
Cretaceous.		
Magothy....	White to chocolate-colored extremely fine loose sand containing small pieces of lignite in rather definite bands. This layer grades horizontally (to the west) into black plastic clay containing much lignite. Many pieces of lignite are coated or infiltrated with pyrite and marcasite. Exposed to water's edge......	5
	Total	16

VII. Section south side of Chesapeake and Delaware Canal 1½ miles east of Pivot Bridge, opposite Milepost 83.

		Feet.
Pleistocene.		
Wicomico..	Reworked Matawan glauconitic sand.................	9
	Pebble and boulder band, some angular boulders as much as 3 feet in greatest diameter.................	3
Cretaceous.		
Matawan.....	Mottled dark micaceous glauconitic sand with blotches of lighter color; discontinuous indurated ledge of iron stone 3 inches thick at base........................	15
Magothy...	Black plastic clay containing much lignite............	1½
	Loose fine white sand containing considerable lignite..	3½
	Loose yellow sand to water's edge..................	1½
	Total	33½

The two lower layers of the above section grade horizontally (to the west) into a layer of black plastic clay containing lignite and siderite nodules.

VIII. Section north side of Chesapeake and Delaware Canal, ¾ mile west of Summit Bridge, between Mileposts 92 and 93.

		Feet.
Pleistocene.		
Wicomico..	Loamy reworked glauconitic sand................	5
	Gravel and pebble lens, some pebbles 4 inches in diameter	1½
	Reworked glauconitic sand......................	3
	Gravel band with matrix of glauconitic sand cemented by iron oxide in places.................	1
Cretaceous.		
Matawan....	Glauconitic sand containing much mica, occasional small pebbles at base.........................	3
Magothy...	Layer lignite with little other material present in certain places while in other places there is a considerable admixture of black plastic clay with fossil plants. Lignitized logs have been bored by Teredo. Occasional siderite nodules at top......	1½–2
	Extremely fine white loose sand in which are thin bands of plastic black clay containing lignite...	6
	Loose buff to yellowish brown to salmon-colored sand containing many irregular iron crusts, some of large size................................	9
	Total......................................	31

IX. Section north side of Chesapeake and Delaware Canal, ⅛ mile west of Summit Bridge, near Milepost 105.

		Feet.
Pleistocene.		
Wicomico..	Reworked glauconitic sand derived from Matawan and containing many small pebbles	10
	Pebble and cobble band cemented by iron oxide in places	1½
Cretaceous.		
Matawan...	Argillaceous greensand, rich yellow in color, due to weathering	4
	Gray (resembling a mixture of pepper and salt) dark green glauconitic micaceous sand	24
	Gray to green glauconitic sand containing ferruginous bands and nodules from ½ to 4 inches in diameter, in which are many fossils of gastropods, pelecypods, ammonites, crab claws, and sharks' teeth with occasional crystals of gypsum	14
	Material similar to above layer but without fossiliferous nodules and bands of ironstone. Exposed to water's edge	12
	Total	65½

X. Section north side of Chesapeake and Delaware Canal 30 rods west of Summit Bridge, just west of Milepost 116.

		Feet.
Pleistocene.		
Wicomico..	Loose coarse buff to yellow cross-bedded sand	7
	Band of pebbles and cobbles ranging in size up to 5 inches in diameter in matrix of yellow sand indurated by iron oxide in places	2½
Cretaceous.		
Monmouth..	Yellowish green to chocolate-colored weathered glauconitic sand containing flattened pellets of clay and small irregular quartz pebbles	3½
	Mottled dark-greenish black to light green glauconitic sand containing angular to subangular quartz pebbles ¼ inch in diameter and water-worn pieces of lignite, some of which are 1 inch in diameter; a few fossil casts of pelecypods and gastropods were noted	4
	Loose gray, buff, to yellow weathered micaceous sand	5
	Loose, ferruginous yellow micaceous sand containing some iron crusts	4
	Light to dark green micaceous glauconitic sand	10
	Concealed to water's edge	12
	Total	48

XI. Section south side of Chesapeake and Delaware Canal, ½ mile east of Summit Bridge, opposite Milepost 136.

		Feet.
Cretaceous.		
Monmouth	Weathered yellowish brown glauconitic sand indurated to form rather firm iron sandstone ledges from 6 to 22 inches in thickness; occasional pockets of fresh glauconitic sand are seen	3
Matawan	Gray to yellow fine micaceous sand grading into underlying stratum	10
	Ferruginous yellowish-brown sand containing crabs' claws	2
	Dark bluish-black argillaceous glauconitic sand. Exposed to water's edge	4½
	Total	19½

XII. Section at mouth of Lloyd Creek, 2 miles east of Betterton, Kent County.

		Feet.
Pleistocene.		
Wicomico	Gravels and boulders cemented to form a ferruginous conglomerate in places, in matrix of loose white to yellow sand	12
Cretaceous.		
Monmouth	Brownish-yellow to gray sand containing many irregular iron crusts roughly arranged in layers	20
Matawan	Mottled drab, light yellow, and brown fine sand in which there are many small pebbles about the size of a pea in the upper portion and in the lower portion numerous elongated compact iron stone concretions from 1 to 4½ feet in height, 1½ feet thick, and 1½ to 4 feet wide in an upright position. Exposed	28
	Total	60

XIII. Section ¾ mile south of Bodkin Point, Anne Arundel County.

		Feet.
Cretaceous.		
Raritan	Clay loam, buff, sandy	7
	Indurated ferruginous layer	2
	Clay, dark drab, containing many lignitized trunks of trees encrusted with pyrite in small well-formed crystals	5
	Clay, mottled	½
	Total	14½

XIV. Section 1¼ miles south of Bodkin Point, Anne Arundel County.

		Feet.
Cretaceous.		
Magothy	Sand, loamy	1
	Sandstone, reddish-brown, ferruginous	3
	Alternating layers of buff, gray, and black sand containing small flakes of muscovite and comminuted lignitized plant remains	1½
	Alternating layers of drab to black clays and fine gray sand. Clay layers contain comminuted plant remains and some small pieces of amber while the sand layers contain much muscovite	2½
Raritan	White sandy clay grading downwards into variegated clay. Exposed	10
	Total	18

XV. Section at Park Point, Magothy River, Anne Arundel County.

		Feet.
Pleistocene	Ferruginous sand with iron crusts	2–5
Cretaceous.		
Matawan	More or less weathered argillaceous, glauconitic and micaceous orange mottled sand	8
	Compact finely micaceous glauconitic, argillaceous, dark greenish fine sand with a few scattered quartz pebbles at the base, forming a sharp contact	5
Magothy	Laminated micaceous, brown, more or less ferruginous sandy clay with whitish sand films and comminuted lignitic materials	2–4
	Massive, very fine gray sand with only slight traces of lignitic materials	3–4
	Rather loose fine buff micaceous stratified sand with thin horizontal seams of comminuted lignite	2–3
	Total	22–29

XVI. Section near North Ferry Point (Cape Sable), Magothy River.

		Feet.
Pliestocene or Recent	Sandy loam	1–3
Cretaceous.		
Matawan	Compact fine sand with disseminated glauconite	3–4
	Compact fine sand with glauconite in pockets about the size of marbles	3–4
	Iron crusts forming a persistent line, in places developing into ledges	4–5
Magothy	Coarse, iron-stained, laminated sands with pellets of amber	15–17
	Black or brownish clays with comminuted lignite	4–5
	Total	30–38

XVII. Section at Stony Point 1 mile above North Ferry Point, Magothy River.

		Feet.
Cretaceous.		
Magothy...	Laminated sands	6–8
	Black, lignitic clays with marked unconformity at base	15–20
Raritan......	Piebald, predominantly red plastic clay	1–4
	Total	22–32

XVIII. Section at Brennen Sand Company's pit, Severn River, Anne Arundel County.

		Feet.
Cretaceous.		
Magothy.....	Small pebbles (1/8 inch) cemented with sand	2
	Coarse sand	1½
Raritan....	Brick-red and gray mottled clay	16
	Tough, plastic, greenish-black clay	5
	Light snuff-colored plastic clay, lower 2 feet showing alternating bands of pink and snuff, varying horizontally to a pure white pottery clay	6
	White sand	3
	Light gray clay, with knife edges of white sand	3
	White glass sand, medium coarse, with some arkose	10
	(The Raritan formation has been shown by borings to continue downwards for 77 feet, the upper 30 feet of this being glass sand)	
	Total	46½

XIX. Section on west side Sullivan Cove, Severn River.

		Feet
Pleistocene.......	Sandy loam	3–4
Cretaceous.		
Matawan....	Fine buff, micaceous sand with weathered glauconite	16
Magothy...	Chocolate-colored sandy clay with lignite and leaf impressions	3–4
	Iron crusts.	
	Chocolate-colored leaf-bearing clay with irregular pockets of white micaceous, somewhat lignitic sand	2
	Orange and buff sand cross-bedded with thin laminæ of chocolate-colored clay and lignitic lens of very coarse sand	0–5
	Argillaceous, laminated lignitic beds	6
	Pyritiferous, micaceous sandy clay	½–3
	Lignitic bed	0–2
	Sandy indurated clay	0–2
	Very white compact sand	3
	Light drab compact sandy clay	4
	Total	36½

XX. Section two-tenths of a mile east of wharf, Round Bay, Severn River.

		Feet.
Cretaceous.		
Matawan	Green, sandy clay, with brown and yellow sand	6
	Chocolate-colored sandy clay, weathered on surface to buff and yellow, grading into member below	6
	Black sandy, glauconitic and micaceous clay, massive	12
	Iron crust.	
Magothy	Very coarse sand, angular and cross-bedded, with considerable lignite	6
	Total	30

XXI. Well at the U. S. Naval Academy, Anne Arundel County, Md.

		Feet.
Recent	Made ground	0–20
Eocene.		
Aquia	Coarse orange sand with some clay and bits of shells	20–40
	Coarse greenish to orange sand with some clay	40–60
Cretaceous.		
Matawan	Fine greenish sand and dark clay	60–140
Magothy	Very tough drab clay	140–180
	Medium gray sand with streaks of light-colored clay; sand water-bearing	180–220
Raritan	Tough clay with fine white sand	220–250
	Fine sand with flowing water	250–270
	Coarse water-bearing sand; flowing water	270–306
	Tough red clay	306–340
	Pink and red clay with coarse sand	340–360
	Coarse brownish sand, water-bearing	360–400
	Coarse light buff sand, water-bearing	400–415
	Pink clay containing gravel	415–435
	Crust of iron ore	435
	Vari-colored sand, water-bearing	435–465
	Crust of iron ore	465
	Vari-colored sand, water-bearing	465–510
	Crust of iron ore	510
Patapsco	Dark-blue clay	510–516
	Very tough red or pink clay	516–548
	Crust of iron ore	524 and 545
	Yellow sand, lower portion coarse and water-bearing	548–583
	Pink clay	583–587
	Coarse sand and gravel—pebbles ½ inch in diameter—large flow of water	587–601
	Very hard rock	601

XXII. Section of well at East Washington Heights, near Overlook Inn, D. C.

			Feet.
Pliocene (?)			
	Lafayette	Loam and gravel	15
Miocene.			
	Calvert	Fine yellow ocherous clay ("marlite") closely jointed with occasional small leaf imprints, grading into mealy sand, iron crusts at summit	40
Cretaceous.			
	Magothy	Dark colored, somewhat glauconitic sand	15
		Light drab laminated sandy clay, at times carbonaceous	8
	Raritan	Loose buff, brown, yellow, gray and white sugary sands, more or less cross-bedded and indurated, with light drab leaf-bearing clay	25
		Massive and stratified bluish-drab clay, at times lignitic and pyritiferous and occasionally blotched with red ocher	10
		White clay in local lenses. Massive and stratified light-colored and drab clay, interbedded	10
	Patapsco	Dense variegated and drab, jointed clay, grading at times into sand, lower portion more or less covered by flanking of Pleistocene and "wash"	100+
		Red and drab clay with ferruginous sandstone largely covered by flanking of Pleistocene and "wash"	70+
	Patuxent	Beginning 20 feet below tide. Cross-bedded arkosic sand, with interbedded clay, estimated	440
Crystallines		At level below tide of 460 feet.	
		Total	733

INTERPRETATION OF THE UPPER CRETACEOUS DEPOSITS

The Upper Cretaceous formations indicate the presence of a great variety of geological conditions during their deposition. During the epoch in which the Raritan beds were being laid down, conditions were more nearly like those of preceding Lower Cretaceous than later in Upper Cretaceous time. A considerable interval must have elapsed, however, after the deposition of the Patapsco formation during which the Lower Cretaceous formations were materially eroded, since the Raritan strata overlie the older beds with a clearly defined erosional unconformity. Furthermore, a very great change in plant life had taken place in the interval between the Patapsco and Raritan epochs.

The Raritan beds are more generally arenaceous than the preceding Patapsco formation and contain but little arkose as compared with the

sands of the Lower Cretaceous formations. The presence of such extensive deposits of arenaceous sediments indicate in all probability a renewed depression of the coastal border and the transportation again of coarser materials into the area of deposition. Many of these materials were doubtless obtained from the earlier Cretaceous strata, but only the more solid quartz grains resisted the processes of transportation. Much, however, was doubtless brought from the Piedmont and Appalachian areas by the streams which had their sources within those regions.

There is no evidence, however, that marine waters entered the region of Raritan sedimentation since no marine fossils have been observed. The irregular and frequent cross-bedding of the strata suggest that the deposition was partially continental in character combined with sedimentation in broad lagoons into which the streams poured a large amount of clastic material. The rapid changes from coarse to fine sand and oftentimes to clays indicates constantly changing currents with the formation of bars and spits on the floors of the lagoons. The discovery in New Jersey of a few molluscan forms of probably estuarine habitat indicates that the sea could not have been far distant.

Some of the less sorted materials suggest fluviatile conditions over portions of the area particularly at the opening of the epoch, while eolian transportation may well have been a factor as we see so frequently to-day in the proximity of coast lines where sandy deposition is taking place.

That an extensive flora covered the coastal border and doubtless spread over the upland areas is clearly evident by the abundance of plant remains which are found at certain points where the sediments were of a type to preserve them. Unfortunately no traces of terrestrial animal life have been detected, although such must have existed in profusion during Raritan time.

The close of Raritan sedimentation was evidently marked by continental oscillations by which the sea floor of that period was elevated and eroded with a subsequent depression that carried the margin lower to the southward than to the northward, with the result that a gradual transgression of Magothy deposits takes place from that direction.

With the opening of the Magothy epoch a considerable change was already manifest, although the lagoons must still have existed over much of the area in which the rapidly alternating arenaceous and argillaceous sediments were deposited. Somewhat varying deposits are found, but in general the strata become persistent over wider areas and marine fossils, such as characterize the Magothy areas in southern Maryland, as well as farther north on the shores of Raritan Bay in New Jersey, indicate the entrance of the sea in places. The area of sedimentation must, however, have been near the shore, for land plants are splendidly preserved at many points and doubtless lived at no great distance from the sea along the coastal border.

The rapidly alternating deposits of sand and clay over considerable areas suggest current changes that may find their explanation in pronounced seasonal differences. In other localities, however, homogeneous deposits of considerable thickness give no such indications.

There is little to suggest any great depth of water in the present known area of Magothy deposition beyond the finding of traces of glauconite in the more marine sediments at one or two localities. Although little is known regarding the actual origin of glauconite, except through the medium of foraminiferal disintegration, yet it is quite conceivable that these slightly glauconitic beds may have been at inconsiderable depths under conditions of slow deposition of terrigenous materials, since so much of the Magothy lithology is littoral in character, as are also the marine faunas.

The close of Magothy time witnessed a further oscillation of the sea floor with probable erosion along the coastal margin but with the early renewal of seaward tilting which for the first time during the Cretaceous period brought the sea widely over this portion of the Coastal Plain. The very marked changes in sediments and the widespread uniformity of materials suggest that the old barriers were broken down as the result of a greater seaward tilting. To the north of Maryland there seems to be some evidence of oscillation during Matawan time in the slight faunal changes recorded, but in Maryland the marine faunas show but slight

differentiation from the beginning to the end of the Matawan time, and although some variations in sedimentation took place, there is no adequate basis for anything but local divisions of the strata.

It is probable that this depression so characteristic of Matawan time may have carried the sea over the area of earlier Cretaceous sediments and on to the Piedmont district, for we find widely scattered through the beds, particularly in the lower strata, a very pronounced admixture of mica flakes making the micaceous sandy clays of this formation among the most diagnostic deposits. No adequate source for these materials can be found in the earlier Coastal Plain formations and it seems likely that they must have been derived from the Piedmont gneisses, either through direct coastal contact or by transportation down the wide rivers into the sea.

The Matawan sediments now preserved in Maryland and farther north show that clearly defined marine conditions had been established over the entire district, but farther south in North Carolina the repetition of marine and nonmarine sediments went on during Magothy and Matawan time as shown in the Black Creek beds of that area. It is evident, therefore, that no great interval of time could have elapsed after the close of the Magothy and the opening of the Matawan, although pronounced physical changes are apparent in the Maryland area.

A much greater change, however, marked the close of the Matawan, and although marine conditions still persisted a very considerable change had taken place in the faunas, while the oscillations of the sea floor caused the transgression of the Monmouth strata southward over the Magothy deposits with the complete overlapping of the Matawan formation. This marked change in the fauna and to some extent also in the sediments indicates that physical and faunal changes of no mean proportions had been initiated. This faunal change has now been traced all the way from New Jersey to the Gulf, and is one of the significant divisional lines in the Cretaceous deposits of the Atlantic border.

The greatly increased proportion of glauconite in the sediments suggests somewhat deeper, or at least more open, seas, free from the influence

FIG. 1.—VIEW OF SECTION ALONG CHESAPEAKE AND DELAWARE CANAL, SHOWING MATAWAN FORMATION OVERLYING MAGOTHY FORMATION.

FIG. 2.—VIEW ON LINE OF CHESAPEAKE BEACH RAILROAD NEAR CENTRAL AVENUE, SHOWING MAGOTHY FORMATION OVERLAIN BY MONMOUTH FORMATION.

of land-derived materials. A very much greater proportion of glauconitic materials at times shows that the seas must have been clear and that most of the terriginous materials had been already deposited near the shoreline of the time.

To the northeast of Maryland later Cretaceous deposits appear, representing the later epochs of the Upper Cretaceous period, but they are absent in Maryland, in all probability because of the extensive transgression of the Tertiary. While in the northern part of the New Jersey Coastal Plain the Eocene deposits succeed the Cretaceous with little or no unconformity, in Maryland the break represents a long interval in time, including not only the later epochs of the Cretaceous but the earliest epochs of the Eocene.

DISTRIBUTION OF THE FAUNA AND FLORA

The following tables show the geological and geographical distribution of the animal and plant remains that have been found in the Upper Cretaceous deposits of Maryland and adjoining areas in Delaware and the District of Columbia. The writer is indebted to Edward W. Berry for the list of fossil plants and to Julia A. Gardner for the list of animal remains. The species in these tables will be fully described in subsequent chapters.

LOCAL DISTRIBUTION

No.	Species	Magothy Formation	Matawan Formation																				Monmouth Formation				
	SPECIES	Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & D)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	VERTEBRATA—REPTILIA																											
1	**Thoracosaurus neocæsariensis**																					*						
2	**Thoracosaurus sp.**																											
3	**Hyposaurus rogersii**																											*
	VERTEBRATA—PISCES																											
4	**Lamna elegans**							*								*												
5	**Lamna cuspidata**																*				*		*					
6	**Corax pristodontus**																				*							*
7	**Corax falcatus**																*				*							
8	**Enchodus dirus**																											
9	**Ischyrhiza mira**																*											
10	**Myliobatis obesus**																											
	ARTHROPODA—CRUSTACEA																											
11	**Holoparia gabbi**																*											
12	**Holoparia gladiator**																*											
13	**Callianassa mortoni**							*													*					*		
14	**Callianassa mortoni var. marylandica**																									*		
15	**Callianassa conradi**																				*							
16	**Callianassa conradi var. punctimanus**																									*		
17	**Callianassa clarki**																*											
18	**Callianassa sp. indet.**																*	*										
	MOLLUSCA—CEPHALOPODA																											
19	**Eutrephoceras dekayi**																											
20	**Baculites asper**							*																				
21	**Pachydiscus complexus**											*																
22	**Baculites ovatus**							*																				
23	**Scaphites hippocrepis**																				*							
24	**Placenticeras placenta**				*				*								*						?*					
25	**Sphenodiscus lobatus**																											
26	**Mortoniceras delawarensis**															*	*											
27	**Belemnitella americana**																								*	*		*
	MOLLUSCA—GASTROPODA																											
28	**Acteon linteus**																											
29	**Acteon gabbana**																											
30	**Ringicula clarki**																											
31	**Cinulia naticoides**																				*							
32	**Avellana bullata**						*			*																		
33	**Avellana costata**																											
34	**Avellana pinguis**																											
35	**Avellana lintoni**																											
36	**Haminea mortoni**																				*							
37	**Haminea cylindrica**																											
38	**Acteocina forbesiana**																											
39	**Cylichna recta**																											

LOCAL DISTRIBUTION																							OUTSIDE DISTRIBUTION																									
Monmouth Formation														Rancocas Formation									New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India			
																																Ripley Formation		Selma Formation														
Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	E. ponderosa zone	E. costata zone	E. ponderosa zone	E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation	
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	SPECIES	LOCAL DISTRIBUTION: Magothy Formation: Good Hope Hill, D. C.	Matawan Formation: Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & I)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	Monmouth Formation: 2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—GASTROPODA—Cont'd																											
1	Morea naticella																											
2	Morea marylandica																											
3	Paladmete cancellaria																											
4	Turris sedesclara																											
5	Turris welleri																											
6	Turris monmouthensis																											
7	Turris terramaria																											
8	Surcula amica																											
9	Olivella monmouthensis																											
10	Rostellites nasutus																							*				
11	Rostellites marylandica																											
12	(?)Rostellites jamesburgensis																											
13	Volutomorpha conradi																											
14	Volutomorpha perornata																											
15	Liopeplum leiodermum																											
16	Liopeplum cretaceum																											
17	Liopeplum monmouthensis																											
18	Vulpecula reileyi																											
19	Xancus alabamensis																											
20	Xancus intermedia						*																					
21	Pyropsis perlata											*																
22	Pyropsis trochiformis																						?					
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28	Serrifusus nodocarinatus																											
29	Piestochilus bella																							*				
30	Odontofusus medians																											
31	(?)Fasciolaria juncea																											
32	(?)Fasciolaria sp.																											
33	Pyrifusus marylandica																											
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35	Pyrifusus whitfieldi																											
36	Pyrifusus cuneus																											
37	(?)Pyrifusus elevata																											
38	Pyrifusus monmouthensis																											
39	Pugnellus densatus																											
40	Pugnellus goldmani																											
41	Anchura rostrata															*	*											
42	Anchura pennata																											*
43	Anchura hebes																											*
44	Anchura pergracilis																											
45	Anchura monmouthensis																											

LOCAL DISTRIBUTION																							OUTSIDE DISTRIBUTION																									
Monmouth Formation														Rancocas Formation									New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India			
																																Ripley Formation		Selma Formation														
Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	E. ponderosa zone	E. costata zone	E. ponderosa zone	E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation	
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LOCAL DISTRIBUTION

	SPECIES	Magothy Formation	Matawan Formation																					Monmouth Formation				
		Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & I)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—GASTROPODA—Cont'd																											
1	Morea naticella																											
2	Morea marylandica																											
3	Paladmete cancellaria																											
4	Turris sedesclara																											
5	Turris welleri																											
6	Turris monmouthensis																											
7	Turris terramaria																											
8	Surcula amica																											
9	Olivella monmouthensis																											
10	Rostellites nasutus																							*				
11	Rostellites marylandica																											
12	(?)Rostellites jamesburgensis																											
13	Volutomorpha conradi																											
14	Volutomorpha perornata																											
15	Liopeplum leiodermum																											
16	Liopeplum cretaceum																											
17	Liopeplum monmouthensis																											
18	Vulpecula reileyi																											
19	Xancus alabamensis																											
20	Xancus intermedia						*																					
21	Pyropsis perlata											*																
22	Pyropsis trochiformis																						?					
23	Pyropsis reileyi																										*	
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41	Anchura rostrata															*	*											
42	Anchura pennata																											*
43	Anchura hebes																											*
44	Anchura pergracilis																											
45	Anchura monmouthensis																											

	LOCAL DISTRIBUTION																							OUTSIDE DISTRIBUTION																								
	Monmouth Formation														Rancocas Formation									New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India		
																																	Ripley Formation		Selma Formation													
	Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	E. ponderosa zone	E. costata zone	E. ponderosa zone	E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	*Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation
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	SPECIES	LOCAL DISTRIBUTION																									
		Magothy Formation	Matawan Formation																				Monmouth Formation				
		Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & I)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—GASTROPODA—Cont'd																										
1	Morea naticella																										
2	Morea marylandica																										
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23	Pyropsis reileyi																									*	
24	Pyropsis septemlirata																										*
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40	Pugnellus goldmani																										
41	Anchura rostrata															*	*										
42	Anchura pennata																										*
43	Anchura hebes																										*
44	Anchura pergracilis																										
45	Anchura monmouthensis																										

No.	LOCAL DISTRIBUTION																							OUTSIDE DISTRIBUTION																								
					Monmouth Formation										Rancocas Formation									New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India		
	Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	Ripley Formation: E. ponderosa zone	Ripley Formation: E. costata zone	Selma Formation: E. ponderosa zone	Selma Formation: E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	*Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation
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	SPECIES	LOCAL DISTRIBUTION																									
		Magothy Formation	Matawan Formation																				Monmouth Formation				
		Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & D)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—GASTROPODA—Cont'd																										
1	Cerithium pilsbryi																										
2	Epitonium marylandicum																										
3	Epitonium cecilium																										
4	Laxispira lumbricalis							*									*										
5	Vermetus circularis																										
6	Serpulorbis marylandica																										
7	Turritella bonaspes	*																									
8	Turritella delmar																*	*									
9	Turritella paravertebroides																										
10	Turritella encrinoides							*																			
11	Turritella trilira																				*		*					
12	Turritella tippana																										
13	Psuedomelania monmouthensis																										
14	Xenophora leprosa																*										
15	Solarium monmouthense																										
16	Gyrodes petrosus							*																			?
17	Polynices altispira																							*				*
18	Polynices halli																						*					
19	Lunatia halli																										
20	Amauropsis meekana																*										
21	Amauropsis compacta																										
22	Margarites depressa																										
23	Margarites abyssina																				*							
24	Margarites elevata																										
25	Discohelix lapidosus																										
	MOLLUSCA—SCAPHOPODA																										
26	Dentalium pauperculum																										
	MOLLUSCA—PELECYPODA																										
27	Nucula slackiana															*								*				
28	Nucula amica																										
29	Nucula microstriata																										
30	Leda whitfieldi																										
31	Leda rostratruncata																										
32	Yoldia longifrons																*										
33	Yoldia gabbana																				*							
34	Yoldia noxontownensis																										
35	Perrisonota protexta																										
36	Perrisonota littlei																										
37	Nemodon eufaulensis																										
38	Nemodon stantoni																										
39	Nemodon cecilius																										
40	Cucullæa vulgaris						*				*	*	*										*	*				*
41	Cucullæa carolinensis											*											*		*			*
42	Cucullæa antrosa																											*
43	Arca obesa																				*							
44	Arca (Barbatia) saffordi																				?							*

LOCAL DISTRIBUTION																							OUTSIDE DISTRIBUTION																									
Monmouth Formation														Rancocas Formation									New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India			
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Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County.	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	E. ponderosa zone	E. costata zone	E. ponderosa zone	E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation	
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	SPECIES	LOCAL DISTRIBUTION: Magothy Formation	Matawan Formation																					Monmouth Formation				
		Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & D)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—PELECYPODA—Cont'd																											
1	Arca (Barbatia) uandi											*																
2	Glycymeris (Postligata) wordeni																											
3	Glycymeris mortoni															*												*
4	Pinna laqueata Conrad																*											
5	Inoceramus confertim-annulatus																											
6	Pteria petrosa																											*
7	Pteria rhombica																											
8	Ostrea larva subsp. falcata			*			*																	*				
9	Ostrea larva subsp. nasuta			?																*		?				*		
10	Ostrea larva subsp. mesenterica																											
11	Ostrea plumosa																											
12	Ostrea monmouthensis																											
13	Ostrea faba																											
14	Ostrea tecticosta																											*
15	Ostrea subspatulata																											
16	Exogyra costata Say												*		*									*	*	*		*
17	Exogyra cancellata						*		*			*		*	*									*		*		*
18	Exogyra ponderosa						*																					
19	Gryphæa (Pycnodonte) vesicularis																											
20	Gryphæa (Pycnodonte) vesicularis, Race A					*	*				*	*															*	
21	Gryphæa (Pycnodonte) vesicularis, Race B					*	*					*	*											*	*			
22	Gryphæa (Pycnodonte) vesicularis, Race C											*												*				
23	Gryphæa (Pycnodonte) vesicularis, Race D																											
24	Gryphæa (Pycnodonte) vesicularis, Race E																											
25	Gryphæa (Pycnodonte) (? vesicularis subsp.) pusilla																											*
26	† Gryphæa (Gryphæostrea) vomer																			?	*	?		*	*			*
27	Trigonia eufalensis																							?				?
28	Trigonia cerulea																											
29	Trigonia marionensis																						*					
30	Pecten argillensis																											
31	Pecten whitfieldi																											
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33	Pecten cliffwoodensis																						*					
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37	Lima reticulata																											
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40	Paranomia scabra										*																	
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42	Anomia argentaria										*									*		*		*				
43	Anomia tellinoides																								*			
44	Anomia ornata																											
45	Anomia forteplicata																											
46	Modiolus burlingtonensis											*																
47	Modiolus trigona																											

† Eocene of the Middle Atlantic Coast and Gulf.

LOCAL DISTRIBUTION

	Monmouth Formation														Rancocas Formation									
No.	Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County.	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.
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OUTSIDE DISTRIBUTION

	New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India		
										Ripley Formation		Selma Formation													
No.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	E. ponderosa zone	E. costata zone	E. ponderosa zone	E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation
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	SPECIES	LOCAL DISTRIBUTION																										
		Magothy Formation	Matawan Formation																				Monmouth Formation					
		Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & I)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—PELECYPODA—Cont'd																											
1	Arca (Barbatia) uandi											*																
2	Glycymeris (Postligata) wordeni																											
3	Glycymeris mortoni															*												*
4	Pinna laqueata Conrad																*											
5	Inoceramus confertim-annulatus																											
6	Pteria petrosa																											
7	Pteria rhombica																											*
8	Ostrea larva subsp. falcata			*			*																	*				
9	Ostrea larva subsp. nasuta			?																*		?				*		
10	Ostrea larva subsp. mesenterica																											
11	Ostrea plumosa																											
12	Ostrea monmouthensis																											
13	Ostrea faba																											
14	Ostrea tecticosta																											*
15	Ostrea subspatulata																											
16	Exogyra costata Say												*		*									*	*	*		*
17	Exogyra cancellata						*		*			*		*	*									*		*		*
18	Exogyra ponderosa						*																					
19	Gryphæa (Pycnodonte) vesicularis																											
20	Gryphæa (Pycnodonte) vesicularis, Race A					*	*				*	*															*	
21	Gryphæa (Pycnodonte) vesicularis, Race B					*	*					*	*											*	*			
22	Gryphæa (Pycnodonte) vesicularis, Race C											*												*				
23	Gryphæa (Pycnodonte) vesicularis, Race D																											
24	Gryphæa (Pycnodonte) vesicularis, Race E																											
25	Gryphæa (Pycnodonte) (? vesicularis subsp.) pusilla																											*
26	† Gryphæa (Gryphæostrea) vomer																			?	*	?		*	*			*
27	Trigonia eufalensis																							?				?
28	Trigonia cerulea																											
29	Trigonia marionensis																						*					
30	Pecten argillensis																											
31	Pecten whitfieldi																											
32	Pecten venustus						*	*				*																
33	Pecten cliffwoodensis																						*					
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35	Pecten simplicius																				*							
36	Pecten quinquecostata		*				*					*												*				
37	Lima reticulata																											
38	Lima serrata																											
39	Lima obliqua																											
40	Paranomia scabra										*																	
41	Paranomia lineata																	*										
42	Anomia argentaria										*									*		*		*				
43	Anomia tellinoides																								*			
44	Anomia ornata																											
45	Anomia forteplicata																											
46	Modiolus burlingtonensis											*																
47	Modiolus trigona																											

† Eocene of the Middle Atlantic Coast and Gulf.

LOCAL DISTRIBUTION																							OUTSIDE DISTRIBUTION																									
Monmouth Formation														Rancocas Formation									New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India			
																																Ripley Formation		Selma Formation														
Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County.	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	E. ponderosa zone	E. costata zone	E. ponderosa zone	E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation	
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	SPECIES	LOCAL DISTRIBUTION: Magothy Formation	Matawan Formation																				Monmouth Formation				
		Good Hope Hill, D. C.	Delaware City, Del.	St. George's, Del.	Post 249 C. & D. Canal, Del.	Post 239 C. & D. Canal, Del.	Post 236 C. & D. Canal, Del.	Post 218 C. & D. Canal, Del.	Post 208n C. & D. Canal, Del.	Post 201 C. & D. Canal, Del.	Post 198 C. & D. Canal, Del.	Post 192 C. & D. Canal, Del. (Camp U & I)	Post 157 C. & D. Canal, Del.	Post 136 C. & D. Canal, Del.	Post 133 C. & D. Canal, Del.	Summit Bridge, C. & D. Canal, Del.	Post 105 C. & D. Canal, Del.	1½ miles east Md.-Del. Line, C. & D. Canal	Cassidy's Landing, Cecil County	Gibson's Island, Anne Arundel County	Ulmstead Point, Anne Arundel County	Head of Magothy River, Anne Arundel County	North Shore Round Bay, Severn River, Anne Arundel County	2 miles west of Delaware City on John Higgins farm, Del.	Post 156, Briar Point, C. & D. Canal, Del.	Head of Bohemia Creek, Del.	Burklows Creek, Del.	Bohemia Mills, Cecil County
	MOLLUSCA—PELECYPODA—Cont'd																										
1	Leptosolen elongata																										
2	Cymbophora berryi																										
3	Cymbophora wordeni																										
4	Corbula bisulcata																				*						
5	Corbula crassiplica																										
6	Corbula monmouthensis																										
7	Corbula terramaria																										
8	Corbula percompressa																										
9	Corbula subradiata																										
10	Panope decisa																*										
11	Panope monmouthensis																							?*				
12	Panope bonaspes	*																									
13	Pholas pectorosa																										
14	Martesia cretacea						?*																				
15	Teredo irregularis							*												*	*						
16	Teredo rhombica																										
	MOLLUSCOIDEA—BRACHIOPODA																										
17	Terebratula harlani Morton																										
	MOLLUSCOIDEA—BRYOZOA																										
18	Stomatopora regularis																										
19	Stomatopora kümmeli																										
20	Berenicea americana																										
21	Crisina striatopora																										
22	Filifascigera megæra																										
23	Lichenopora papyracea																										
24	Membranipora annuloidea																										
25	Amphiblestrum heteropora																										
26	Escharinella ? altimuralis																										
27	Cribilina sagena																										
28	Membraniporella abbotti																										
29	Mucronella aspera																										
30	Hippothoa tenuichorda																										
	VERMES																										
31	Serpula whitfieldi																										
32	Serpula trigonalis																										
33	Hamulus onyx																				*						
34	Ornataporta marylandica																										
	ECHINODERMATA—ECHINOIDEA																										
35	Cidaris sp.																										
36	Cassidulus sp.																										
37	Cardiaster marylandica																										
38	Hemiaster delawarensis				*																						
39	Hemiaster sp.																	*									
	COELENTERATA—ANTHOZOA																										
40	Trochocyathus ? vaughani																										
41	Micrabacia rotatilis																										
42	Micrabacia marylandica																										

LOCAL DISTRIBUTION: Monmouth Formation														Rancocas Formation									OUTSIDE DISTRIBUTION: New Jersey				The Carolinas			Eastern Gulf						Texas			Western Interior			Europe			South India			
Right bank Bohemia Creek near Scotchman's Creek, Cecil County	Cayot's Corners, Cecil County	Fredericktown, Cecil County	Mouth of Turner's Creek, Kent County	Millersville, Anne Arundel County	Waterbury, Anne Arundel County	Brightseat, Prince George's County	R. R. cut west of Seat Pleasant, Prince George's County	Brooks Estate near Seat Pleasant, Prince George's County	Friendly, Prince George's County	1 mile west of Friendly, Prince George's County	McNeys Corners, Prince George's County	2 miles south of Oxon Hill, Prince George's County	Fort Washington, Prince George's County	South side Appoquinimink Creek, Del.	Noxontown Pond, Del.	South feeder Noxontown Pond, Del.	Near Noxontown Pond, Del.	Magothy formation of Md.	Matawan formation of Md. & Del.	Monmouth formation of Md. & Del.	Rancocas formation of Del.	Manasquan formation of Del.	Magothy formation	Matawan formation	Monmouth formation	Rancocas formation	Middendorf beds	Black Creek formation	Peedee formation	Tuscaloosa formation	Eutaw formation	Ripley Formation: E. ponderosa zone	Ripley Formation: E. costata zone	Selma Formation: E. ponderosa zone	Selma Formation: E. costata zone	Austin formation	Taylor formation	Navarro formation	Colorado group	Pierre formation	Fox Hills formation	Emscherian	Campanian	Aturian	Ootatoor formation	Trichinopoly formation	Arrialoor formation	
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SPECIES	LOCAL																		OUTSIDE														
	Raritan Formation									Magothy Formation																						
	Bull Mt., Cecil Co., Md.	Shannon Hill, Cecil Co., Md.	Cedar Point, Baltimore Co., Md.	Forked Creek, Anne Arundel Co., Md.	Drum Point R. R., Anne Arundel Co., Md.	Brightseat, Prince George's Co., Md.	Glymont, Charles Co., Md.	East Washington Heights, D. C.	Overlook Inn Road, D. C.	Deep Cut C. & D Canal, Del.	Grove Point, Cecil Co., Md.	Bodkin Point, Cecil Co., Md.	Cape Sable, Anne Arundel Co., Md.	Round Bay, Anne Arundel Co., Md.	Little Round Bay, Anne Arundel Co., Md.	Millersville, Anne Arundel Co., Md.	Raritan formation of Md.	Magothy formation of Md.	Raritan formation of Mass., N. Y. & N. J.	Magothy formation of Mass., N. Y. & N. J.	Middendorf beds, South Carolina	Black Creek formation, North & South Carolina	Tuscaloosa formation of Eastern Gulf	Eutaw formation of Eastern Gulf	Woodbine formation of Texas	Dakota group of Rocky Mts. and Great Plains	Colorado group of Rocky Mts. and Great Plains	Montana group of Rocky Mts. and Great Plains	Atane beds of Greenland	Patoot beds of Greenland	Cenomanian of Europe	Turonian of Europe	Senonian of Europe
FUNGI																																	
Sphærites raritanensis														*				*	*							o							
ALGÆ																																	
Algites americana														*				*				*											
PTERIDOPHYTA																																	
Gleichenia zippei *										*								*	*	*								*	*	*	*		*
Gleichenia delawarensis										*	*							*															
Gleichenia saundersii														*				*		*													
Osmunda delawarensis										*								*															
Onoclea inquirenda														*				*		*	*								*				
Cladophlebis socialis	*																*												*				
Asplenium cecilensis											*							*											o				
Asplenium dicksonianum *	*							*									*		*							*			*				
Lycopodium cretaceum															*			*			*		*										
CYCADOPHYTA																																	
Williamsonia delawarensis										*	*							*															
Williamsonia marylandica															*			*															
Podozamites lanceolatus *	*																*		*			*			*						*		
Podozamites knowltoni *														*				*	*			*				*							
Podozamites marginatus					*												*		*				*						*		o		
CONIFEROPHYTA																																	
Dammara cliffwoodensis															*	*		*	o	*			o						o				
Araucaria bladenensis											*						*			o			*		*						o	o	o
Auracaria marylandica															*			*															
Brachyphyllum macrocarpum										*	*							*	*			*				*					o		
Brachyphyllum macrocarpum formosum														*				*	*			*	*	*	*		*				o		
Protophyllocladus lobatus														*				*			*										o		
Protophyllocladus subintegrifolius											*							*	*	*			*			*			*				
Sequoia heterophylla										*	*				*			*	*	*		*	*					*	*		*		
Sequoia ambigua *														*				*		*			*			o			*				
Sequoia reichenbachi *										*	*			*	*			*	*	*	*	*	*	*		*	*	*			*	*	*
Cupressinoxylon (?) bibbinsi													*					*															
Thuja cretacea										*	*							*	*									*	*				
Juniperus hypnoides										*								*	*	*									*				
Widdringtonites reichii										*	*			*				*	*	*			*			*			*	*	*		
Raritanis gracilis										*	*							*	*														
Geinitzia formosa										*								*	?	*			?									?	*
Czekanowskia capillaris				*													*		*														
Moriconia americana										*	*			*				*		*	*	*											
ANGIOSPERMOPHYTA																																	
Carex clarkii										*	*							*		*	*												
Doryanthites cretacea														*				*		?		*		*							o		
Pistia nordenskioldi											*							*				*						o	*			o	

† Occurs also in late Lower Cretaceous

SPECIES	LOCAL																		OUTSIDE														
	Raritan Formation									Magothy Formation																						
	Bull Mt., Cecil Co., Md.	Shannon Hill, Cecil Co., Md.	Cedar Point, Baltimore Co., Md.	Forked Creek, Anne Arundel Co., Md.	Drum Point R. R., Anne Arundel Co., Md.	Brightseat, Prince George's Co., Md.	Glymont, Charles Co., Md.	East Washington Heights, D. C.	Overlook Inn Road, D. C.	Deep Cut C. & D Canal, Del.	Grove Point, Cecil Co., Md.	Bodkin Point, Cecil Co., Md.	Cape Sable, Anne Arundel Co., Md.	Round Bay, Anne Arundel Co., Md.	Little Round Bay, Anne Arundel Co., Md.	Millersville, Anne Arundel Co., Md.	Raritan formation of Md.	Magothy formation of Md.	Raritan formation of Mass., N. Y. & N. J.	Magothy formation of Mass., N. Y. & N. J.	Middendorf beds, South Carolina	Black Creek formation, North & South Carolina	Tuscaloosa formation of Eastern Gulf	Eutaw formation of Eastern Gulf	Woodbine formation of Texas	Dakota group of Rocky Mts. and Great Plains	Colorado group of Rocky Mts. and Great Plains	Montana group of Rocky Mts. and Great Plains	Atane beds of Greenland	Patoot beds of Greenland	Cenomanian of Europe	Turonian of Europe	Senonian of Europe
ANGIOSPERMOPHYTA—Cont'd																																	
Sabalites magothiensis										*	*			*				*		*													
Myrica longa											*	*		*	*			*					*		*	*			*	*		*	
Salix flexuosa										*	*			*				*	*	*	*	*	*	*		*							
Salix lesquereuxii								*		*	*						*	*	*	*	*	*	*			*							
Populus stygia												*		*				*		*						*			*	*			
Quercus morrisoniana														*				*		*													
Quercus severnensis														*				*							*	*							
Ficus daphnogenoides										*	*							*	*	*	*	*	*										
Ficus ovatifolia								*									*		*	o	o	*	o	*									
Ficus cecilensis											*							*								*							
Ficus crassipes										*	*				*			*		*	*	*	*	*		*			*				
Ficus krausiana											*							*		*	*	*	*	*		*					*	*	
Platanus heerii					*			*									*									*			*		o		
Aspidiophyllum trilobatum		*		*				*									*									*							
Protophyllum sternbergii	*	*						*									*									*							
Protophyllum multinerve			*					*									*																
Coccolobites cretaceus											*							*															
Magnolia hollicki											*							*	*	*			*			*							
Magnolia lacœana											*							*	*	*			*						o				
Magnolia longipes											*							*	*				*			*							
Magnolia obtusata											*							*		*	*		*		*	*			*				
Magnolia boulayana											*			*				*	*	*			*	*		*							
Magnolia tenuifolia										*								*		*						*							
Magnolia capellinii											*			*				*		*		*	*	*					*		*		
Illicium deletoides											*							*								*					o		
Carpites liriophylli										*								*															
Nelumbites primæva														*				*		*					*	o							
Cinnamomum newberryi								*		*	*			*	*		*	*	*	*	*		*	*	*	*					o		
Laurus proteæfolia											*			*				*		*					*	*							
Laurus plutonia											*			*				*	*	*	*		*	*					*		?		
Laurus hollickii										*	*			*	*			*		*													
Laurophyllum elegans										*				*				*	*		*	*											
Laurophyllum angustifolium											*							*	*	*						*							
Sassafras acutilobum						*		*			*						*	*	*	*			*								?		
Leguminosites canavalioides											*							*								*							
Leguminosites coronilloides											*							*	*	*						*			*				
Leguminosites omphalobioides											*							*					*										
Liriodendropsis constricta											*							*		*			*										
Colutea obovata											*							*					*			*							
Colutea primordialis											*							*	*	*									*				
Bauhinia marylandica											*			*				*					*										
Dalbergia severnensis															*			*															
Crotonophyllum cretaceum											*							*			o												
Ilex severnensis															*			*															
Elæodendron marylandicum											*							*															
Celastrus arctica															*			*	*	*										*			
Celastrophyllum crenatum											*							*	*		*		*							*			

SPECIES	LOCAL — Raritan Formation									LOCAL — Magothy Formation							LOCAL		OUTSIDE														
	Bull Mt., Cecil Co., Md.	Shannon Hill, Cecil Co., Md.	Cedar Point, Baltimore Co., Md.	Forked Creek, Anne Arundel Co., Md.	Drum Point R. R., Anne Arundel Co., Md.	Brightseat, Prince George's Co., Md.	Glymont, Charles Co., Md.	East Washington Heights, D. C.	Overlook Inn Road, D. C.	Deep Cut C. & D. Canal, Del.	Grove Point, Cecil Co., Md.	Bodkin Point, Cecil Co., Md.	Cape Sable, Anne Arundel Co., Md.	Round Bay, Anne Arundel Co., Md.	Little Round Bay, Anne Arundel Co., Md.	Millersville, Anne Arundel Co., Md.	Raritan formation of Md.	Magothy formation of Md.	Raritan formation of Mass., N. Y. & N. J.	Magothy formation of Mass., N. Y. & N. J.	Middendorf beds, South Carolina	Black Creek formation, North & South Carolina	Tuscaloosa formation of Eastern Gulf	Eutaw formation of Eastern Gulf	Woodbine formation of Texas	Dakota group of Rocky Mts. and Great Plains	Colorado group of Rocky Mts. and Great Plains	Montana group of Rocky Mts. and Great Plains	Atane beds of Greenland	Patoot beds of Greenland	Cenomanian of Europe	Turonian of Europe	Senonian of Europe
ANGIOSPERMOPHYTA—Cont'd																																	
Celastrophyllum undulatum														*				*	*				*								o		
Rhamnites apiculatus														*				*								*							
Cissites newberryi										*								*		*													
Cissites formosus var magothiensis											*							*	o							o			o		o		
Hedera cretacea										*								*								*							
Hedera cecilensis											*							*		*													
Sterculia minima										*	*							*		*						o							
Sterculia cliffwoodensis										*								*		*													
Eucalyptus attenuata											*			*				*	*	*		*	*										
Eucalyptus latifolia														*				*		*			*										
Eucalyptus geinitzi										*	*			*	*			*	*	*	*	*	*		*	*			*		*	*	
Eucalyptus wardiana										*	*			*				*	o	*		o		o							o		
Cornus cecilensis											*							*															
Cornus forchhammeri											*							*											*				
Aralia grœnlandica														*				*	*	*						*			*				
Aralia ravniana											*							*		*									*				
Aralia washingtoniana								*									*		o														
Araliopsoides breviloba	*																*																
Araliopsoides cretacea	*	*				*	*	*	*								*									*							
Araliopsoides cretacea dentata	*																*						o			*							
Araliopsoides cretacea salisburifolia	*																*									*							
Andromeda cookii											*			*				*	*				o			o			o				
Andromeda parlatorii										*	*			*				*	*	*	*	*	*	*		*			*				
Andromeda novæ-cæsareæ											*			*				*	*	*	*	*	*	*	*	o							
Andromeda grandifolia											*							*	*	*		*	*										
Myrsine borealis											*							*	*	*		*	*			o			*				
Myrsine gaudini											*							*	*		*	*	*			*							
Sapotacites knowltoni										*								*								*					o		
Bumelia prænuntia											*							*	o							o							
Diospyros primæva	*											*					*	*	*	*	*	*	*	*	*	*			*	*	*	*	
Diospyros rotundifolia										*	*							*		*	*		*			*							
Diospyros vera								*									*		o														
Cordia spiculata										*								*	*				*										
Fontainea grandifolia				*													*		*														
Carpolithus septloculus										*										*													

THE GEOLOGIC PROVINCE

The Maryland Upper Cretaceous formations comprise part of a nearly continuous belt that extends from Maryland northward through Delaware and New Jersey to the islands off the New England coast as well as to southern Massachusetts. Although transgressed by Tertiary deposits in Virginia they reappear in surface outcrops in North Carolina where they present somewhat different characters and where the strata have been described under different names. From this area they have been traced southward to the Gulf, where they again take on different characters and have been described under still other names. Even within the northern area the strata are in places transgressed by Tertiary or Quaternary deposits, the latter at times covering the Upper Cretaceous beds extensively in the interstream areas, while in the extreme northern part of the district the surface continuity of the beds is broken by bays and estuaries.

Unlike the Lower Cretaceous strata which attain their most complete development in Maryland, the Upper Cretaceous formations of this northern district are best developed in New Jersey, the Maryland deposits representing the gradual thinning out of these formations to the southward. It is significant that the Lower Cretaceous formations are overlapped northward by the Upper Cretaceous and are unknown in the northern part of New Jersey Coastal Plain and in the islands off the New England coast, whereas the transgressions hitherto described within the Upper Cretaceous are developed to the southward with the gradual overlapping of the several formations in that direction. These transgressions, within the Upper Cretaceous, however, are not of equal significance, although clearly defined in each instance. The Monmouth transgression is apparently more pronounced than the Magothy and the Matawan, since the Monmouth deposits entirely transgress the Matawan and come to rest on the Magothy in the southern part of the district.

The most extensive development of the Upper Cretaceous series within the province is to be found in Monmouth County, New Jersey, where each of the formations attains large, if not in each case maximum, thickness and where the differentiation of the deposits and faunas has led to the

description of a larger number of locally developed formations than are recognizable elsewhere. The names employed in the present report with the exception of the term Magothy, introduced by Darton, were employed by the writer in New Jersey for those formational units which can be traced throughout this northern Upper Cretaceous province. Whether these divisions in New Jersey should be subdivided into members or formations and the larger units regarded as formations or groups, as the case may be, is of little consequence, but they must be retained as formational names south of the Delaware basin since the features relied upon for their subdivision in central New Jersey are not recognizable outside that state. Not only are the formations described in an earlier chapter as occurring in Maryland present, but still later formations known under the name of the Rancocas and Manasquan formations, the former of which has been traced through Delaware to the Maryland Line, although the subdivisions described for the New Jersey area are not recognizable south of that state. The Manasquan formation, however, is known only in New Jersey and even in that state is much restricted in its development. It is possible that this formation likewise participates in the southerly transgression characteristic of the older Upper Cretaceous formations, but there is no positive information on this subject.

Deep-well borings near the margin of the Coastal Plain in Virginia at Old Point Comfort and at Norfolk show that deposits of Upper Cretaceous age occur beneath the cover of the Tertiary formations, and represent one or more of the formations developed farther north. The materials penetrated are very similar to those characteristic of the Magothy-Monmouth series of formations, and consist of coarse and fine sands and even of pebbles as well as clays of dark color with lignite and, even more striking, of the dark sandy micaceous clays and greensands so characteristic of the Matawan and Monmouth. At the same time a considerable number of fragmentary fossils have been secured which present more particularly a Matawan aspect, although a single specimen has been questionably referred to a species found only in the Rancocas. The total thickness of these buried Upper Cretaceous deposits in Virginia has been estimated at 65 feet to 75 feet, but may be considerably greater. It is

apparent, however, that the Upper Cretaceous formations of Maryland are continued to the southward beneath the Tertiary formations into southern Virginia, a region which must have been much more extensively depressed during Tertiary time than Maryland and the district to the north of it to have buried the Upper Cretaceous so deeply beneath the later deposits. Whether more of the section penetrated by the well borings should be assigned to the Upper Cretaceous or whether the strata of this age have materially thinned along the dip cannot be determined from present knowledge. The facts in any event are far too meager to determine the location of the coast line in Virginia during this period.

It seems equally probable that the Virginia strata were likewise connected on the south with those of North Carolina where deposits representing the Magothy-Matawan-Monmouth series are represented in the Black Creek-Peedee series. There is no definite evidence of the existence of the Raritan formation in the Virginia well borings, and it is quite certainly absent in North Carolina, together with the Patapsco and Arundel formations of Lower Cretaceous age. A much greater interval is therefore represented between the Lower and Upper Cretaceous strata in North Carolina than in Maryland, although the formations absent in this district may have been overlapped and actually exist farther seaward. The Black Creek formation, as already pointed out, contains both the flora of the Magothy and the fauna of the Matawan in interbedded layers and lacks the single change from non-marine to marine deposits shown in the northerly area in passing from the Magothy to the Matawan. Although the physical conditions existing in North Carolina must therefore have been somewhat different from those farther north, there is little doubt that these deposits must be linked through Virginia with those of the northern Atlantic Coastal Plain in the same general province of deposition. The Peedee formation presents so many characteristics in common with those of the Monmouth formation that although they are separated by wide areas of overlapping Tertiary formations these deposits must be considered as probably forming a continuous belt of sedimentation with the more northern areas.

There is likewise little doubt that the area of sedimentation represented in the North Carolina deposits was continued southward along the continent border into the Gulf district where the Cretaceous strata attained such extensive development in the Tuscaloosa, Eutaw, Selma, and Ripley formations which, as will be shown later, are regarded as representing the Raritan, Magothy, Matawan, and Monmouth formations of the northern area. It seems probable, therefore, when viewed in its broader relations, that the northern province was connected with the south Atlantic and Gulf provinces and that the same general conditions were continuous throughout the entire area of the Atlantic and Gulf borders.

When the conditions that existed in Upper Cretaceous time along the Atlantic and eastern Gulf borders are considered, it is apparent that both in the north and in the south—in New Jersey, Delaware, and Maryland on the one hand, and in western Alabama on the other—the Upper Cretaceous of these areas was inaugurated with extensive deposits of non-marine character which evidently spread widely over the eastern and southern lowlands of the then existing Coastal Plain. It is not difficult to believe that similar deposits were being formed during this time over much of the intervening areas, although such deposits have not been observed nor any others which might represent them. Following the Raritan epoch in the north and the evidently somewhat later Tuscaloosa epoch in the south, came the transgression of the marine waters of the continent border which so far buried the earlier Upper Cretaceous deposits south of Maryland to the eastern Gulf area that no trace of these formations has been found, if perchance they escaped the erosion to which they are known to have been subjected even within the area of their outcrop. That they may ultimately be discovered in deep-well borings is quite possible, but their absence along the line of outcrop is but another proof of the differential movements that have taken place since the deposition of the earliest Lower Cretaceous strata within this area and which have been somewhat strikingly exemplified in the relations of the Upper Cretaceous formations already described.

FIG. 1.—VIEW OF SECTION NEAR BRIGHTSEAT, PRINCE GEORGE'S COUNTY.

FIG. 2.—VIEW OF SECTION NEAR BRIGHTSEAT, PRINCE GEORGE'S COUNTY, SHOWING MONMOUTH FORMATION OVERLAIN BY AQUIA FORMATION.

A somewhat similar problem presents itself in the presence of later Cretaceous formations in New Jersey and their absence elsewhere along the coastal border. Gradual transgression of first the Eocene and then the Miocene, followed by the extensive cover of Pleistocene deposits, suggests the possibility that deposits of equivalent age to the Rancocas and Manasquan may exist farther to the eastward in Maryland and thence southward to the Gulf. The only evidence that has ever been introduced in support of this view is the questionable determination of *Terebratula harlani* from the well boring at Old Point Comfort. It would not be at all surprising if deposits of this and even Manasquan age were found in deep-well borings along the continent border. A discovery of diagnostic fossils of these horizons would add a notable chapter to the history of the Atlantic Coastal Plain.

The following table presents in tentative form the relations of the Upper Cretaceous deposits in the Atlantic and eastern Gulf areas.

Europe.	Islands off the coast of New England and New York.	New Jersey.	Delaware.	Maryland.	North Carolina.	Alabama.
Danian.		Manasquan.				
		Rancocas.	Rancocas.			
Senonian.	?	Monmouth.	Monmouth	Monmouth.	Peedee.	Ripley and Selma.
	Matawan.	Matawan.	Matawan.	Matawan.	Black Creek.	Eutaw.
Turonian.	Magothy.	Magothy.	Magothy.	Magothy.		Tuscaloosa. (W. Ala.)
Cenomanian.	Raritan.	Raritan.	Raritan.	Raritan.		

THE PETROGRAPHY AND GENESIS OF THE SEDIMENTS OF THE UPPER CRETACEOUS OF MARYLAND

BY

MARCUS I. GOLDMAN

Introductory

The object of this chapter is to present the results of the detailed study and the mechanical and microscopical analysis of a few typical sediments from the Upper Cretaceous of Maryland. Work of this kind is merely an extension of petrography to the sedimentary rocks; yet it has hitherto been so little practised that most geologists hearing the term petrography think instinctively of crystalline rocks. This comment is made in order to forestall an attitude of mind towards what follows that is very general, namely the belief that after such an analysis of a sedimentary rock it is possible to determine the conditions under which the rock originated. That is, of course, the ultimate object of such work, yet it is no more implicitly the immediate result of the study of a given rock than the study of a given crystalline rock in the beginning of that science was the direct key to the origin of the rock—or is to-day, for that matter. If decades of study of conglomerates, whose composition is apparent to the unaided eye, leave many fundamental problems concerning this relatively simple type of rock still unsolved, it is not to be expected that microscopic knowledge of facts of the same kind about the sedimentary rocks of finer grain will suddenly reveal the conditions of their origin. In fact, for these finer-grained rocks, as for the conglomerates, field study of their larger geological characters, their variations vertically and horizontally, the form of the whole mass, its relations to adjacent beds, and other features must remain as important as the laboratory analysis. But a more detailed knowledge of the composition of the finer-grained sedi-

mentary rocks is desirable than the current terms, sandstone, shale, sandy shale, tuff, limestone, or even more circumscribed terms like chalk, greensand, etc., afford; and from the awakening interest in this subject it is safe to expect that before long every stratigraphic study of a limited region will contain descriptions of the composition of the sedimentary rocks involved. Every such study will bring out some significant facts regarding the origin of the particular rocks, but for a satisfactory final interpretation of the conditions under which the rock originated it will be necessary to have accumulated an extensive series of analyses of modern sediments of all possible varieties. Comparing then the ancient sediment with the modern ones, the conditions of whose origin will be more or less completely known, it will be possible by finding the modern sediment that is most similar to determine the conditions under which the ancient sediment in question was formed. On the other hand, the sediments of the past offer some opportunities to the investigator that are lacking in the modern. For in the subaqueous sediments of to-day only what is at the surface, or a few feet below, can be examined. Of the ancient sediments, however, it is possible to obtain sections in which the changes both vertical and lateral can be followed out, and thus knowledge gained which could be gathered from sediments in process of formation only through centuries of observation or through periods too long for consideration. Thus the two branches of the study must advance together, each throwing light on the facts of the other, and the two pointing out to each other the problems that require special attention.

It is this consideration that has led to the attempt to interpret freely the facts obtained in the present study in the belief that an investigation is valueless until some conclusion has been drawn from it, and that the investigator who has accumulated the facts is in the most advantageous position for interpreting them. These interpretations, however, are put forward most tentatively and with the greatest possible reservation.

While the published literature describing modern sediments is not inconsiderable,[1] it is not of much value for the Cretaceous sediments

[1] For a very full and up-to-date bibliography, see Andrée, K., Ueber Sedimentbildung am Meeresboden Geol. Rundschau, vol. 3, 1912, H 5/6, pp. 324-338.

because most of it deals with the deposits of the deeper ocean, little with the deposits near and adjacent to the mouths of rivers. Probably no investigator of modern sediments has had the geologic bearings of the study so forward in his mind as Thoulet, and it is his publications therefore, limited in extent though the work of one man must be, that are of most value to the geologist. Foremost in his work in this connection stands the recently published monograph, with colored maps, of the sediments of the Gulf of Lyon;[1] and the work of his pupil Sudry[2] on the Lagoon of Thau in the same region is, as subsequently pointed out, probably of particular bearing on the Matawan. (See especially sample 8, below.)

References to such studies as have been made of near-shore sediments will be found in Andrée's bibliography, but as far as I know the only systematic and continuous investigation of this type, and the only one whose results are expressed in the tangible form of a map is that by Thoulet of the Gulf of Lyon. In fact it is, I believe, the need for studies of this kind that inspired him to carry out the work.

THE METHOD OF ANALYSIS

In all essentials it is Thoulet's[3] method of analysis that has been followed in this investigation.

In a general way three main types of procedure in the analysis of unindurated sediments, whether ancient or modern, may be recognized. The first is the method of elutriation in which a separation, mainly of the clay and finer parts from the sand, is made by subjecting the sample to a rising current of water whose velocity is known and can be regulated. This method cannot be used, however, to subdivide material finer than $\frac{1}{4}$ mm., because finer particles settle too slowly to oppose any velocity of current

[1] Thoulet, J., Etude bathylithologique des côtes du Golfe du Lion. Annales de l'Inst. Océanograph., T. iv, Fasc. 6, Paris, 1912, 66 pp. Maps.

[2] Sudry, L., L'Etang de Thau. Ann. de l'Inst. Océanograph., T. i, Fasc. 10, Monaco, 1910, 208 pp.

[3] Thoulet, J., Précis d'analyse des fonds sous-marins actuels et anciens. Paris: Chapelot et Cie, 1907, 220 pp.——Instructions pratiques pour l'établissement d'une carte bathymétrique-lithologique sous-marine. Bull. de l'Inst. Océanograph., No. 169, Monaco, 1910, 29 pp.

that is practically attainable. Theoretically there would seem, however, possibilities of its unlimited extension to finer sizes in the centrifugal elutriator of Yoder,[1] in which the velocity that the particles oppose to the current is greatly increased by centrifugal force.

The second method, developed by Mitscherlich,[2] determines the relative internal surface of a soil. There are two distinct procedures for arriving at this quantity. The first is based on the fact that when water is brought into contact with a perfectly dry porous or powdered substance a certain heat is developed which is a function of the internal surface of the substance. The finer its particles the greater, of course, will this surface be, and the greater, therefore, the heat developed. In practice it is more convenient to adopt the second procedure, which determines the hygroscopicity of the substance, that is, the amount of water which the material will take up out of a saturated atmosphere. This quantity, as explained by Mitscherlich, is also supposed to have a definite relation to the internal surface.[3]

The third method, and the one most generally employed, is that of sieving the sands in conjunction with washing out the mud. It is to this group that the method of Thoulet belongs, as well as that of Murray, the U. S. Department of Agriculture, and others. To these methods are added certain accessory procedures (the essential part of some less generally practised methods) such as treatment in heavy liquid, by the electromagnet, with acids, etc.

There is no room for lengthy discussion of the relative values of these three methods; but for the purpose in hand the method by elutriation is theoretically and practically the most satisfactory,[4] since it classifies the

[1] Yoder, P. A., Bull. No. 89, Utah Exper. Sta., 1904.

[2] Mitscherlich, E. A., Bodenkunde, Berlin, 1905, pp. 49-70.

[3] An attempt to eliminate the effect of the internal surface of the *particles* (that is minute fissures or pores in them) has been made by Franz Scheefer: Eine Methode zur Bestimmung der äusseren Bodenoberfläche. Dissert. Königsberg. i. Pr., 1909.

[4] Thoulet, Précis d'analyse (op. cit.), 65-67.——Hilgard, E. W., Soils. 1906, pp. 90-93.——Ries, H., Clays. 1906, pp. 113-115.——Andrée, K., Ueber Sedimentbildung am Meeresboden (op. cit.), pp. 350, 351.

sediments by the relative settling velocities of their constituents, which is the significant factor in sedimentation, and, on account of the time allowed for working over the material in the elutriator, tends to classify them very successfully. Its defect is the great amount of distilled water, time, and attention it requires. The method of determining surface by heat of moistening or hygroscopicity seems to have the defect that it gives only a single value for each sample, so that sediments made up of very different proportions of the various sizes might yet give the same results. It is really a method that has much more significance for soils, for which it was devised, than for sediments to which it has, however, been very recently applied.[1]

The method here followed, which is that of Thoulet with some modifications as will be noted, is essentially as follows: A large portion of the sample is first passed through sieves with respectively 3, 6, and 10 meshes to the inch, and the portion retained is classed as gravel, though concretions of these sizes should of course be separately considered. As a matter of fact, none of the samples contained any gravel that would not pass the 3-mesh sieve; very few, indeed, any gravel at all, and then only very little. As the material was dried at 105° it was necessary to know the proportion of gravel in such dried material, but it would not have been pratical to dry the large portion required for gravel determination. The whole lot was therefore weighed merely air-dried, and at the same time a small portion weighed separately, dried for about eight hours at 105° C., and the percentage loss in drying determined. This loss was then applied to the large lot in which the gravel had been determined. For the rest of the analysis about 10 gm. of the sample, if necessary crushed somewhat in order to facilitate drying, is dried for about eight hours at a temperature maintained as nearly as possible at 105°. The sample was cooled in a dessicator and weighed rapidly; but the avidity with which the dried samples took up moisture gave an accuracy of not more than 5 mg. to 10 mg. The balance, moreover, that was used for the later

[1] Küppers, E., Physikalische u. mineralogisch-geologische Untersuchung von Bodenproben aus Ost- u. Nordsee. Wiss. Meeresuntersuch. Herausgegeb. v. d. Kommiss. z. Untersuch. d. deutsch. Meere, etc., 1908, N. F., vol. x, pp. 1-11.

analyses did not have a reliable accuracy of more than 5 mg., which is the smallest unit to which weights were then recorded. The sample was next washed into an 8 oz. milk-sterilizing bottle with water and generally a little ammonia to help disintegrate the clay. The bottle was then shaken on a rotary shaker. This is simply an axis to which a board is fastened. The bottle is attached to the board at right angles to the axis with the middle of the bottle over the axis, so that when the axis is rotated the sediment and water, which should less than half fill the bottle, flop from one end of the bottle to the other twice in one revolution and by this jarring the sample disintegrates. The method seemed fairly effective; just how effective it is hard to say. Certainly in some of the samples there was a perceptible amount of clay granules, a little in all; they are mentioned in some of the analyses that follow, though they are not consistently recorded. But it is a question whether, in some cases at least, these clay granules are not an essential part of the sediment representing some kind of growth or concretion in the clay. That there is a possibility of the existence of such concretions is indicated by the round, clay-like granules with faint aggregate polarization that were found in a few of the samples (see sample 4) and believed to represent a stage intermediate between clay and glauconite. The uncertainty prevailing in the whole matter appears from the difference of opinion concerning the best method of disintegrating clay, Mitscherlich, *e. g.*, recommending that the sample be boiled some fifteen minutes, while others say that only luke-warm water should be used, because hot water coagulates the clays.

After being shaken ten to thirty hours, according to the apparent amount of clay in the sample, the material is washed out of the bottle into an evaporating dish of 12 cm. diameter. Here it is allowed to settle for a while, the mud decanted into a 1500 c. c. separating funnel, hot wash water added in the evaporating dish, the settling and decantation repeated, etc., several times. The length of time during which the material was allowed to settle varied for different samples and decreased for each successive decantaion. If the sample was muddy the writer started with fifteen minutes, allowed ten minutes on the second settling and so on down, depending somewhat on the observed rate of clearing of the upper part of

the suspension. This appears to have been more time than Thoulet allowed, but it was probably on this account that very little residue from the material tapped from the separating funnel was obtained. Another slight adaptation of Thoulet's method consisted in fixing the time for the last settling at thirty seconds. That is, all the " sand " and " silt " had to settle in that time. This period was chosen on the basis of practical experience with the samples, which showed that the interval was sufficient to allow all but a certain cloudiness to settle out. In many samples, however, it was found that there was a sort of transition material which not only had a different appearance from the sand but also did not seem to settle with the same promptness as the sand, forming a sort of intermediate constituent. Microscopic examination justified this conclusion as, according to the constitution of the sample, irregular glauconitic fragments, limonitic fragments, or small clay flakes secondarily cemented appeared in this intermediate product. The determination of the amount of this product settling in thirty seconds but not in ten, was most unsatisfactory, since the quantity depended largely on the amount of water in the evaporating dish, the temperature of the water as affecting convection currents, and probably other factors, so that it was possible to wash back much of the material that had once been washed out, and vice versa, by continuing washing to keep on almost indefinitely washing out a little more silt from the sand. Any absolute value, of course, the portion settling between thirty and ten seconds has not in any case, since it represents no distinct pure product of any kind; but even its relative amount in different samples has no great precision. Actual results, however, as given in the following analyses, show that the differences in quantity are marked enough in some cases to indicate roughly the amount of this product, and thus to give some indication of the extent of the processes—in most cases probably subsequent to the formation of the sediment—which have produced it. Besides, since the material is finer grained than the extra fine sand, it is, in the end, according to Thoulet's classification, counted with the clay to determine the amount of mud, so that the separation of it does not affect the final numerical result.

The clay washings in the large separator funnel were allowed to settle for about half an hour, the settlings tapped and rewashed for any sand or silt that might have escaped the first washing. The amount, as indicated above, was usually very small. This method of separating sand and "clay" is in principal entirely similar to the method of the Bureau of Soils of the U. S. Department of Agriculture.[1] The use of the centrifuge by the Bureau of Soils merely hastens settling. Their method differs mainly in having definite size limits for the finer portions of "silt" and "clay." But the analysts of the Bureau of Soils themselves recognize that a perfect separation is never attained and that it is indeed theoretically possible only if all the particles treated have the same density and shape. But if other conditions remain constant the same result is attained by allowing the particles to settle a definite length of time through a fixed distance, so that theoretically the method of Thoulet, as used, gives the same results, even though time of settling instead of prevailing size of particles settled is used as the determining factor.

In general, it must be said, and is admitted by all students of sediments, that all such mechanical methods of separating sand and "clay," while they allow valuable comparison, are, from a scientific standpoint, still most unsatisfactory. It is now generally believed that the colloidal state, in which true clay may be assumed to be, is merely a certain state of subdivision between fairly definite limits ($100\mu\mu$ to $10\mu\mu$) in a continuous series from grains visible to the unaided eye to molecular solution. If this is so, then any separation of what might be called true clay, even if it were mechanically possible, would still be somewhat arbitrary. Moreover, there is some reason to doubt that in a natural sediment there actually exists such a continuous series rather than a mixture of certain definite consituents or groups of constituents each with its own size limits, the limits overlapping more or less.

The ideal solution of the problem would be to establish a curve showing the rate at which the settling of the constituents of a given sediment progresses. That different constituents can be differentiated in the finest

[1] U. S. Dept. Agric. Bureau of Soils, Bull. No. 24, 1904; Bull. No. 84, 1912.

portion by this method is indicated by the work of Mohr,[1] who carries his settling to periods of several weeks. But he too separates between arbitrary limits and his curve is therefore not continuous. Moreover, his results show that in the very finest portions some further differentiation could probably be made.

To go into a more detailed discussion of methods other than the mechanical for the differentiation of the constituents of argillaceous sediments would not be in place here. Reviews and discussions of such methods can be found in a paper by Stremme and Aarnio, "Die Bestimmung der anorganischen Kolloide," etc., Zt. f. prakt. Geol., vol. xix, 1911, pp. 329-335, and van der Leeden und Schneider, "Ueber neuere Methoden der Bodenanalyse u. der Bestimm. der Kolloidstoffe im Boden," Int. Mitt. f. Bodenkunde, vol. ii, 1912, pp. 81-109, in which, among others, the method of Mitscherlich referred to above is discussed. There may also be much to be learned about the colloidal matter by the method of staining and microscopic study in which a beginning has been made by Hundeshagen.[2] But it may be said in conclusion that the analysis of clay-bearing sediments on a scientific basis, that is, on the basis of their natural constituents, has not yet been attained.

To continue the description of the method of analysis that has been employed in the present study, the clay suspension in the funnel was tapped into a large evaporating dish. Thoulet, who, working with fresh modern sediments, was not obliged to add ammonia to disintegrate, then added a few drops of alum solution to precipitate the clay, settled, siphoned off as much of the supernatant water as possible, and evaporated to dryness over a gentle heat. As ammonia was used in most of the present analyses, it had to be neutralized, which was done with hydrochloric acid. Performed at first approximately, this neutralization produced irregular results due doubtless to solution with an excess of acid, while to neutralize exactly was very tedious. Moreover, experiment with one sample showed

[1] Mohr, E. C. Jul., Mechanische Bodenanalyse. Bull. Dépt. de l'Agr. aux Indes Néerlandaises No. 41, Buitenzorg, 1910, 33 pp.——Ergebnisse mech. Analysen tropischer Böden. *Ibid.* No. 47, 1911, 73 pp.

[2] Hundeshagen, Ueber die Anwendung organischer Farbstoffe zur diagnostischen Faerbung mineralischer Substrate. Neues Jahrb. f. Min. etc. Beilage-Bd. xxviii, 1909, pp. 335-378.

that hot water dissolved a small portion of it, partly salts, partly a tough, almost white, colloidal substance, so that in the later analyses the whole quantity was evaporated down on a steam bath. The dried clay was scraped out of the dish with a steel spatula, a process which always involved some loss, partly from a small residue that adhered, partly from dust that was carried away. The clay was then dried for eight hours or more at about 105° C., cooled in a desiccator and weighed as rapidly as possible.

The sand separated from clay and silt was air-dried, weighed and then passed through a series of sives made of bolting cloth with approximately 30 (28), 60, 100 (97), and 200 meshes, respectively, to the inch.[1]

Following, according to Thoulet's observations,[2] are the minimum sizes of the materials held back by the different sieves:

		= Coarse sand.
30..................	0.89 mm.	
		= Medium sand.
60..................	0.45 "	
		= Fine sand.
100..................	0.26 "	
		= Very fine sand.
200..................	0.04 "	
		= Extra fine sand.

Even this simple process of sieving is not quantitatively absolute which, as indicated above, is one of the reasons for preferring the elutriation method. The two causes are: most important of all that the grains are not round; a minor factor that the meshes, especially in the finer bolting cloths, are not uniform. As a result of the irregular form of the grains, very long grains with a short diameter less than the mesh opening will pass, and with prolonged shaking very many of them. The duration of the sieving is, therefore, a matter of accommodation based largely on personal judgment and experience. The procedure was to stop when the grains that came through were predominantly elongated. But this stage will be

[1] The figures in parentheses are the given meshes, according to trade numbering, which were the nearest that could be obtained. The actual mesh, according to measurement, is still somewhat different, in most cases fewer meshes per inch or larger openings. Professor Thoulet was, however, good enough to assure the author that these were quite accurate enough.

[2] Thoulet, J., Précis d'analyse (op. cit.), p. 64.

reached much sooner with the coarse than with the finer sizes. As the coarse material was, besides, usually less abundant the coarsest size was not generally shaken more than a minute, while the finest, that is, that on the 200-mesh sieve, when it was abundant required sometimes more than half an hour. The amount of shaking that each size received depended on the abundance of the material of that size, the sizes being successively removed from the nest of sieves, in the order of their fineness, while the finest was continued until observation, with the hand lens, of the material passed showed that predominantly elongated grains were coming through. The sieves were shaken by hand. The Department of Agriculture uses a mechanical shaker in which the sieves are left for about three minutes. Thoulet's principle is to continue shaking until a considerable shaking passes only a negligible amount of material,[1] as it would require an excessive length of time to produce an absolutely complete separation of the finer sizes. But his limit, which is also only approximate, agrees quite closely with the present, since, when dominantly elongated grains come through, the rate of separation is very slow. The products of sieving are weighed and put aside for study.

Finally the "very fine sands" are separated according to their specific gravity by means of Thoulet's solution, of a density slightly greater than 2.7. The most serious defect of this separation in the rocks studied was due to the glauconite. Fresh glauconite is lighter than all the feldspar and quartz, so that it remains in the light portion and can subsequently be in turn separated by its density. But in all the glauconitic rocks considered in the following the greater part of the glauconite sank with the "heavies" and was made up of grains ranging in density in many cases from less than 2.7 + to higher than 3.00. This is doubtless due to weathering effects. An exact determination of the amount of glauconite by weight was therefore impossible, and even the fairly close approximations that were obtainable with a solution of specific gravity of 3.00 and the electro-magnet to be mentioned below, are not quite comparable on account of the difference in density of the lots from different

[1] Thoulet, J., Précis d'analyse (op. cit.), p. 64.

samples. The importance of considering the glauconite separately is, however, evident, since in many of the samples it has been formed in place and not brought in like the rest of the material.

Except for separating the glauconite the electro-magnet plays no inherent part in the analysis of the samples. It has been used merely to segregate different minerals in order to facilitate the study of them. The magnetic permeability of different minerals is distinct, so that, by introducing various resistances in the circuit of the magnet, they can be segregated. Thoulet has for his magnet a table showing the current that will attract each mineral, but this varies so with the particular constitution, and doubtless also with the amount of decomposition of the mineral, that it affords only an approximate indication in practice. It was found most practical to try different strengths of current and examine the product with the hand lens, until a satisfactory separation was obtained. One of the most refractory minerals in both the gravity and magnetic separation is mica. While it tends to accumulate in certain portions, the segregation is always far from perfect, and, moreover, in transferring it there are always losses said to be due to static electric charges which cause it to adhere to the surfaces with which it comes in contact. This very static electric property can be used to separate it from other minerals, but this procedure has not been applied in the present study.

While the method thus described includes all the steps employed in a complete analysis it appeared, when the results began to accumulate, that some of the separations could not yield information of any value in certain sediments, or at least that more results of importance could be accumulated by not making each analysis so systematically complete; hence in a few of the later ones some of the steps are omitted.

The quantitative results of the mechanical analyses are represented in the diagrammatic form (pp. 169, 170) so effectively used by Mohr in the papers referred to above.[1] The construction of these diagrams is very

[1] While Mohr devised these diagrams quite independently, exactly the same type of diagram, differing only in scale, was used at an earlier date by J. A. Udden, "The mechanical composition of wind deposits." Augustana Library Publ. No. 1, 1898, 69 pp.

simple. The amount of each portion is represented by a vertical column of which the height corresponds to the percentage of the portion present in the whole sample. The columns are all of the same arbitrary width and the successive sizes are placed side by side, the vertical boundaries between them being the limit of size that separates them. Their significance may be most readily conceived by imagining the columns to represent small sample tubes containing the different portions and placed side by side in order of their size of grain.

Finally, mention must be made of a serious defect in the entire analysis of many samples, which arises from the abundance of carbonaceous organic matter present. Even a determination of it by quantitative analysis, if it did not involve an amount of time disproportionate to the advantage to be derived, would probably not give entirely accurate results. Keilhack[1] describes a common method of determination by burning off the carbonaceous matter, but this has so many defects that it scarcely seems worth using. It is probably largely on this account that the Bureau of Soils of the Department of Agriculture takes no cognizance of carbonaceous matter, which practice has been followed in the present study. However, a specific gravity separation might be used here to float off the carbonaceous matter, at least in the sands, with results of a degree of accuracy equal to that of the other separations. Certainly in some of the sediments that in the following pages have been called of the "delta" type the proportion of carbonaceous matter is so great that it interferes seriously with the value of the results of the analyses.

[1] Keilhack, Lehrbuch der praktischen Geologie, 1908, p. 540.

THE ANALYSES

SAMPLE NO. 1 (FIG. A, p. 169)

Serial number[1] : 7.
Field number : 1[10]-10-2-1911.
Formation : Magothy.
Locality : Betterton.
Appearance : A compact, massive, homogeneous, slightly greenish-gray, fine-grained, micaceous, argillaceous sand.

MECHANICAL ANALYSIS

Sample .... 11.040 gm.

	Per cent of sample
Sands	73.4
Clay	26.1
	99.5

	Per cent of total sands
Coarse sand	.4
Medium sand	7.0
Fine sand	14.4
Very fine sand	45.3
Extra fine sand	33.2
Total	100.3

	Per cent of very fine sand
Light	89.3
Heavy	10.0
	99.3

MAGNETIC SEPARATION	Per cent of total heavies
Attracted at 2000 ohms	43.65
S. G. > 3.002 15%	
S. G. < 3.002 (glauconite) 80.2% = 32.35% of heavies = 3.20% of very fine	
Attracted at full current	37.10
S. G. < 3.002 (mica) = 23.45% of heavies	
S. G. > 3.002 largely pyrite concretions	
Non-magnetic	1.70
Magnetite	17.40[2]
	99.85

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS[3]

There is very much carbonaceous plant matter which gives all the sands a dark, blackish-gray appearance.

The coarse, medium, and fine-grained sands all show a considerable proportion of well-rounded and smoothed quartz grains. They are all three speckled with the argillaceous grains described under the very fine light portion, the proportion of these increasing in the finer portions. Smooth limonitic grains occur in all of the portions, perhaps from the alteration of glauconite grains. Heavy minerals seem to be very scarce in these coarser portions though mica is scattered through the "fine-grained" sands.

[1] The serial number is the number given to the analysis when it was made, indicating the order in which the samples were taken up, hence not corresponding to the present order which is stratigraphic.
[2] High magnetite.
[3] Magnification × 10.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Ratio of quartz to feldspar estimated 90 : 10.[1]

With the light portion there is separated an abundance of grains of a translucent to opaque, humus-brown substance full of small dark granules. The substance is isotropic, index of refraction 1.55-1.56. It crushes plastically under the knife. Probably it is a combination of organic and inorganic colloidal matter, with inclusions of granules that may be both mineral and carbonaceous but are not fresh mineral grains.

(2) Heavy

Dominant.—Glauconite in worn grains; percentage as given.

Abundant.—Magnetite, garnet, epidote, muscovite, pyrite in granular concretions.

Rarer.—Tourmaline, staurolite, chlorite, biotite, topaz, rutile, zoisite, zircon, enstatite, kyanite, anatase (dumortierite?).

The well-rounded form of the magnetite grains is noteworthy.

II. Finer Portions

The finer portions (extra fine, silt, and clay) show little of special interest. The clay is gray with a strong humus-brown stain, and contains unusually much of a dirty fibrous matter that is common in many of the samples.

Summary and Conclusions.—Noteworthy are:

(1) The abundance and variety of heavy minerals.

(2) The high percentage of magnetite with associated garnet and epidote.

(3) The fact that the glauconite is all rounded, *i. e.*, reworked.

(4) The rounded clay-like grains. These may be merely undisintegrated clay, though their abundance would seem to indicate some concretionary process, perhaps the first stages in the formation of glauconite, as will be explained in the general discussion of glauconite (see p. 176 below). The abundance of pyrite in the sample, however, suggests that pyrite may have something to do with the formation of these granules, though I believe such a process has not hitherto been recognized.

(5) The pyrite concretions. Pyrite concretions are, under certain conditions, formed in waters in which abundant organic matter is decomposing.

(6) The lack of sorting indicated by the abundance of several different sizes of sand and the high percentage of magnetite and garnet.

[1] The ratio of quartz to feldspar was determined by making several counts, in different parts of the slide, of all the grains in the field of view of a No. 4 objective and determining the number of these that were feldspars. The feldspars were rather readily picked out, following Thoulet, with the aid of a liquid of index 1.548 (the mean index of quartz), checked when necessary by determining the optical figure. The average as will be seen, is always given to the nearest 5 units. The relative sizes of the grains was not considered, so that the results have no absolute quantitative value. They do serve, however, to indicate the relative abundance in different samples.

SAMPLE NO. 2 (FIG. B, p. 169)

Serial number : 10.
Field number : 1[4]-10-2-1911.
Formation : Magothy.
Locality : Betterton.
Appearance : A hard, blue-gray, faintly laminated clay in layers about 1 inch thick with sandy partings.

MECHANICAL ANALYSIS

Sample	14.050 gm.
	Per cent of sample
Sands	14.2
Silt	13.2
Clay	66.8
Total	94.2
	Per cent of total sands
Coarse sand	0.7
Medium sand	6.6
Fine sand	6.3
Very fine sand	43.9
Extra fine sand	42.7
Total	100.2
	Per cent of fine sand
Light	87.5
Heavy	12.4
Total	99.9

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

The coarse portion is only carbonaceous matter; the medium-grained contains, in addition, small rounded pyrite nodules, grains and flakes of argillaceous matter, but as primary minerals only a few flakes of mica. The fine-grained contains more of the clay grains, and mica more abundant and in greater variety, there being chlorite as well as muscovite.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar=85 : 15.

Besides feldspar and quartz carbonaceous fragments and argillaceous grains as in the coarser portions, are important constituents. These two constituents are, in fact, so abundant that they interfered with the study of the quartz and feldspar. A portion was therefore incinerated and with the aid of this incinerated portion the following facts could be determined.

The plant fragments appear in two forms, one black and opaque, the other brown, translucent, and generally showing some organic structure. The incinerated portion turned from black to red. Under the microscope it was then found that most of the opaque black fragments had disappeared but the brown translucent remained with all their structure, having apparently only turned red. It may be that some of the translucent had also disappeared but the essential point is that many of them, at least, were evidently permeated, or perhaps partly replaced, by some iron salt which on incineration preserved the form of the original plant fragment.

Here too the clay grains, found in the other portions as well, could be studied under the microscope. The facts about them may therefore be summarized. They are round

or flaky in form. The smaller sizes are translucent, of a humus-brown color, filled with small opaque flakes and grains. They crush plastically but the crushed portion reveals no new characters.

Essentially they are probably true clay and their appearance is that of the greater part of what is separated as clay. But it is important to know whether they are merely undisintegrated portions of clay, or whether they are minute concretions. The flaky form of many of them supports this latter hypothesis, suggesting their formation in moulds such as the plant fragments might afford. For the present, however, the question must remain undecided.

(2) Heavy

The heavy minerals are:

Abundant.—Muscovite, chlorite, serpentine.

Rarer.—Tourmaline, glauconite, garnet.

Essentially the heavy portion is muscovite, with some chlorite and serpentine, tourmaline and garnet being exceedingly rare. Of glauconite there are very few grains, many of them weathered yellow.

II. Silt

Dark dirty, brownish-black, micaceous. The dark color appears to be due mainly to the great amount of black carbonaceous matter which is probably responsible for the high percentage of silt separated from this sample, though the large proportion of the finest-grained sands is probably also a factor in this result. The carbonaceous matter not only contributes to the silt itself but also catches up many grains of fine sand which are floated off with it. There is very little argillaceous matter and that in irregular floccules, not in the rounded grains noted in the very fine light portion.

Summary and Conclusions.—Noteworthy are:

(1) The very small proportion of sands and the large proportion of clay.

(2) The very high proportion of carbonaceous matter.

(3) The granules of argillaceous matter and the pyrite concretions as in sample 1. The sample seems to be, like sample 1, high in heavy minerals, but this is deceptive since micas are the principal constituent of the heavy portion, and these in spite of their specific gravity are classed, in the processes of sedimentation, rather with the light and fine-grained minerals.

SAMPLES NO. 1 AND NO. 2

General Summary and Conclusions.—While sample 2 is markedly different from sample 1 in the much lower percentage of sand, in the general dominance of the fine-grained materials, and in the scarcity of heavy minerals other than mica, it still has in common with it certain features that are essential. Foremost among these is the wide range of size in the sands; for while these are dominantly finer-grained they do not show that dominance of any one size that is characteristic of the most typical marine sediments which have been subjected to the sorting action of strong waves. This is at once apparent from an inspection of the diagrams of these two

sediments (A) and (B), p. 169, with the diagrams on p. 170, representing various types of deposits. The high percentage of carbonaceous matter is also a characteristic of both samples. Both contain concretionary pyrite grains or small nodules, and in both there are the peculiar clay granules that have been noted.

Before interpretation of the beds is attempted their manner of occurrence in the field should be taken into account. This is characterized above all by the rapid and rather extreme alternation of the beds between the two types, sandy and argillaceous, as fairly well represented by these two samples. Carbonaceous matter is conspicuous, also micaceous beds, while thin films of whitish sand between the beds are a characteristic peculiarity.

The mechanical analyses of sediments, that are represented on p. 170, are not numerous enough nor sufficiently correlated with the exact conditions of their formation to justify direct matching of the above analyses with them. They illustrate certain general factors in sedimentation rather than definite types of sediment, and this first discussion of them may therefore be made a general introduction.

The principal factors in the diagrams are: (1) The *maximum*, that is, the predominant portion. Both the extent to which it exceeds the other portions as an indication of the degree of sorting of the sediment, and the size which it represents as indicating the strength of the sorting agent are significant. (2) The *sharpness of the " curve,"* as Mohr calls it, on each side of the maximum, that is, the extent to which the maximum exceeds the portions on both sides of it. (3) The general form of the curve, especially whether it shows more than one maximum. This last feature, however, while theoretically important is evidently very much influenced by the degree and limits of subdivision of the sample. In the diagrams of these Cretaceous sediments the only second maximum is that representing the clay portion, but that this would in most cases probably disappear is indicated by the analyses given by Mohr.[1] He makes many subdivisions of the portion classed as clay in Thoulet's method of analysis, with the result that there is often a steady fall of the curve through these portions.

[1] Mohr, E. C. Jul., Ergebnisse mech. analysen, etc. (op. cit.).

An examination of the diagrams on p. 170 leads to the recognition of the following general effect of different conditions and agents on the diagrams. Most conspicuous is the difference in the degree of sorting or sizing. The most complete sizing is produced by strong waves and by wind action (p. 170, figs. A, C, J, K, L). Off-shore marine sediments (p. 170, fig. C) are as well sorted as beach sands, differing only in having the maximum in a finer size. A similar difference in the maximum appears between dune sands of temperate regions (p. 170, fig. J) and those of tropical regions (K, L), and though this might be due to a difference in the part of the dunes from which the different samples were taken, it is also quite possible that the prevailing winds of these tropical regions are stronger.

But while the deposits found respectively under the influence of winds and of strong waves thus agree in their perfection of sizing, they also show a certain difference in that, in the product of wave action, after the maximum the largest portion is the next finest material, while in the eolian deposit the next coarsest is generally the largest.[1]

The lagoonal deposits may be taken as representing in general deposits in a small body of water in which there is much weaker wave-action and less room for the horizontal separation of sizes than in the ocean. Consequently sizing is less perfect (p. 170, figs. E, F).

River sediments in addition to being poorly sized tend, as explained by Mohr,[2] to show an abrupt rise of the curve on the left and a gentle fall on the right. That is, sedimentation of streams is likely to take place from a sudden change in velocity; hence all of the coarsest and much of the finer material that it has been able to carry to the point of sedimentation will suddenly drop out. This is well illustrated by the typical diagram, M, p. 170.

Delta deposits show a combination of this stream effect with a certain amount of sorting as can be seen in diagrams D and I, pl. II, but the sorting effect of wave action appears very rapidly away from the edge of a marine delta.[3]

[1] See further, Udden, J. A., The mechanical composition of wind deposits. Augustana Library Publ. No. 1, 1898.

[2] Mohr, E. C. Jul., Ergebnisse mechanischer analysen, etc. (op. cit.), p. 35.

[3] See some of the analyses in Thoulet's study of the Gulf of Lyon, cited above.

This general view of sedimentation diagrams affords a sufficient basis for the special consideration of the sediments discussed in this chapter, To turn then to samples 1 and 2.

No detailed field and laboratory study of delta sediments has been published, to the writer's knowledge; but from what little can be learned of such deposits it appears that the beds from which samples 1 and 2 are taken show many of the characteristics of delta formations. In their field relations the rapid alternation, the extremes represented, the thin partings of sand, and the abundance of carbonaceous matter support this view. And consideration of the conditions of sedimentation in a delta leads to the same conclusion, for, according to the principle laid down by Johannes Walther, only such facies can succeed each other as can exist side by side. Now, in a delta there is a sharp difference between the channels and the waters lying to the side of them, so that in one there would be deposited relatively coarse sand, while in the other fine sediments would slowly settle. Then sudden changes of channel, such as would be produced by high water in a region with the extremely low relief of a delta, would bring two such facies into vertical succession, producing the type of section seen at this locality. The sandy partings, on the other hand, would result merely from the passing conditions of a single flood without a change of channel.

The mechanical analyses, also, fall in with this general view. To be sure, A, p. 169 (= sample 1) and E, p. 170 (= a lagoon sediment) show a similarity which amounts almost to identity. But the quiet, open bodies of water in a delta would, in their conditions of sedimentation, be entirely equivalent to a lagoon, like that from which E, p. 170, is derived. In B, p. 169, the upper shaded portions of the five left-hand columns represent the analysis recalculated to a basis of 100 after subtracting the clay and silt, and in this form the similarity of the diagram to a stream sediment like M, p. 170, with the abrupt rise of the curve on the left and the poor sorting, is strikingly brought out. Both these analyses therefore fit in well with the conditions that would exist in a broad delta.

Formation of pyrite is another characteristic of such deposits. It is due, as noted above (Sample No. 1, *Summary and Conclusions*), to the H_2S

liberated by the decay of organic matter, but requires slow circulation of the water in which the H_2S is liberated, so that the gas may not be carried off as quickly as it is formed. Thus pyrite grains are characteristic of the deeper, stagnant water of the Black Sea, and the writer has a carbonized fragment of wood collected from the East River at New York, encrusted with pyrite. The pyrite grains in the coarsest sediment (sample 1) were therefore probably carried into it from some stagnant portion of the delta invaded by a change of current.

A peculiar feature, perhaps related to the pyrite formation, was noted in the "light" portion of sample No. 2. Black opaque, and brown translucent carbonaceous matter was so abundant that a portion was incinerated to free it from these particles. The effect of incineration was to give the sample a reddish color, but a large part of the organic fragments remained. Evidently then they had been impregnated or partly replaced by some iron salt, very possibly by pyrite.

Some such process may also account for the abundant clay granules noted in both samples. The flat form of many of these is against the assumption that they are merely undecomposed clay fragments, since in that case they would more probably have been developed, in shaking, with rounded form. The flat shape indicates rather that they were formed in some mould with that shape, perhaps in the carbonaceous plant fragments, where they may well have shared in the impregnation with an iron salt shown by the plant fragments themselves. This problem, however, requires further study. The facts are, as far as I know, new.

Of great geologic interest, though not bearing immediately on the conditions of origin of this deposit, is the occurrence of glauconite in both of the samples. It shows that conditions favorable to the formation of glauconite existed previously even farther inland than this region. Since there is no trace of a glauconitic deposit, older than these beds, known in the region, there must have been a considerable transgression in early Magothy or pre-Magothy times of which the deposits have been subsequently entirely eroded.

It is further worth noting, though without much more extensive field study the fact must not be given too much weight, that this particular

facies of the Magothy occurs here at the head of Chesapeake Bay, therefore just below the mouth of the present Susquehanna. It points to the possible existence of that stream in Cretaceous times.

SAMPLE NO. 3 (FIG. C, p. 169)

Serial number : 13.
Field number : 3-7-13-1911.
Formation : Matawan.
Locality : Chesapeake and Delaware Canal.
Appearance : Typical Matawan ; black glauconitic clay with little mica.

MECHANICAL ANALYSIS

Sample	8.967 gm.
	Per cent of sample
Sands [1]	64.8
Silt	6.3
Clay	27.0
Total	98.1
	Per cent of total sands
Coarse sand	4.8
Medium sand	5.3
Fine sand	5.7
Very fine sand	59.4
Extra fine sand	24.8
Total	100.0 [1]
	Per cent of very fine sand
Light	71.2
Heavy	26.3
Total	97.5

MAGNETIC SEPARATION

	Per cent of heavies	
Attracted at 2000 ohms (glauconite) [2]	63.7	=16.8% of very fine
Attracted at full current	28.6	= 8.3% of very fine
Non-magnetic	0.5	
Magnetite	2.9	
Total	95.7	

	Per cent of 2000-ohms portion	
Attracted at 2000 ohms, S. G. > 3.002	12.0	
Attracted at 2000 ohms, S. G. < 3.002 (glauconite) [2]	87.1	=14.6% of very fine
Total	99.1	

[1] Total sands by summation of parts.
[2] The separation with the solution of density 3.002 was made to facilitate study of the rare heavy minerals. A small part of the glauconite came down with the heavy minerals while much mica remained floating with the glauconite. The value for percentage of glauconite after the separation at density 3.002 is, however, probably nearer right than before this separation, so that *glauconite* may be taken as about 15% of the very fine sand, leaving about 11% of true heavy minerals.

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

(a) Fairly well rounded grains of quartz mostly white opaque, almost all, however, much pitted and corroded as if by solution.

(b) Next in abundance are rounded concretions formed of grains of fresh-looking glauconite, quartz, etc., cemented by limonitic matter.

(c) Some of the quartz is of the black granular concretionary type (cf. Sample No. 13) suggesting secondary origin in the sediment.

II. Medium Sand

(a) Angular quartz grains predominate, though there are still some very well rounded; there is also more glassy, less opaque quartz.

(b) The *glauconite* is mostly in rounded grains; most of those that are not rounded suggest by the irregularity of their form a secondary concretionary origin from botryoidal grains. There are a very few normal botryoidal grains all somewhat rounded. The proportion of glauconite is small.

(c) There are limonitic sand concretions as in the coarse sand but more rough and irregular, less rounded.

(d) Considerable white mica.

(e) Black carbonaceous fragments.

(f) Shell (?) fragments stained brown.

III. Fine Sand

Its general appearance is dark greenish-black, speckled.

(a) Quartz predominantly glassy and angular.

(b) Glauconite as in preceding but much more abundant.

(c) Limonitic sand concretions as in preceding.

(d) Much white mica.

(e) Many black carbonaceous fragments.

IV. Very Fine Sand

General appearance much like the fine sand.

V. Extra Fine Sand

Dark blackish-gray. Appear much like the preceding portion.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar = 90 : 10

The feldspars appear unusually decomposed. No plagioclase was found.

There is little glauconite and mica left.

Both quartz and feldspar show much ocherous staining.

A grain was noted made up of individual grains of quartz differently oriented in a cloudy quartz cement of homogeneous orientation, believed to be derived from quartzite.

(2) Heavy

(a) Attracted at 2000 ohms heavier than 3.002.

The abundant minerals, in the approximate order of their frequency, are:

Abundant.—Glauconite in translucent to nearly opaque olive-green grains, chlorite, biotite unusually abundant, epidote.

Rarer.—Garnet, tourmaline, muscovite, staurolite, rutile.

(b) Attracted at 2000 ohms lighter than 3.002.

Not especially studied. Almost pure glauconite with some mica.

(c) Full-current product.

A brownish-yellow, micaceous sand.

Abundant.—Muscovite, chlorite, quartz. This is doubtless separated here on account of its heavy ocherous stain.

Rarer.—Tourmaline, epidote, biotite, asbestos (?).

(d) Non-magnetic.
Zircon and enstatite, about equally abundant. Kyanite very rare.
(e) Attracted by permanent magnet: Mainly magnetite but with much chlorite, some biotite, and a little glauconite. Magnetite in very angular grains.

II. Extra Fine Sand

Mainly quartz with some glauconite and mica.

III. Silt

Dark gray with a yellowish tint. Many limonite flakes. Much mica. A fibrous serpentinous mineral common.

IV. Clay

Yellowish showing much limonitic matter. Much fibrous matter.

Summary and Conclusions.—The most striking feature of this bed is the evidence of *reworking* of the material in it. Thus, except in the coarsest sand, there is almost no glauconite in primary botryoidal form, the grains being mostly rounded.

I think the ocherous stain of the grains throughout, the sand-ocher concretions, and the weathered condition of the feldspars may be interpreted in the same way, for it does not seem as though such products could be formed in a sediment as argillaceous as this while, moreover, the bed itself remained black and free from ocherous stain. It seems more probable that they originated in a more open-textured glauconitic sand exposed to atmospheric agents before its constituents were reworked and redeposited in this bed.

The other principal feature is the evidence that seems to me to point to something like a delta facies for this bed. The factors indicating this are:

1. The mechanical composition of the sediment as shown in C, p. 169 (*cf.* D and J, p. 170). The material is seen to be unsorted, all sizes being well represented, though the three finest largely predominate. This poor sorting suggests a small body of water, either a lagoon or a quiet open stretch of water in a delta, while the sharp rise of the curve from the fine to the very fine sand with a slow drop to the right has been shown in the general discussion of these diagrams to be characteristic of stream sediments.

2. The abundance of mica.

3. Abundance of carbonaceous matter.

4. The high percentage of heavy minerals, especially the rather large proportion of magnetite.

Finally, there are to be especially noted the black concretionary quartz grains which, for the present, I shall not discuss (see p. 175, below).

SAMPLE NO. 4 (FIG. D, p. 169)

Serial number : 14.
Field number : 4-7-13-1911.
Formation : Matawan.
Locality : Chesapeake and Delaware Canal.
Appearance : A fairly light-gray, very micaceous, fine-grained, argillaceous sand; no glauconite apparent.

MECHANICAL ANALYSIS

Sample	7.510 gm.
	Per cent of sample
Sands	68.1
Silt	1.1
Clay	29.5
Total	98.7
	Per cent of total sands
Coarse sand	0.4
Medium sand	1.4
Fine sand	3.1
Very fine sand	72.8
Extra fine sand	21.4
Total	99.1
	Per cent of very fine sand
Light	88.4
Heavy	9.8
Total	98.2

MAGNETIC SEPARATION

Magnetic	98.1
Non-magnetic Magnetite	1.9
Total	100.0

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Consists of 13 flakes of white mica and one very lustrous black carbonaceous flake.

II. Medium Sand

Almost all mica, mostly white with some brown and pale green flakes. Carbonaceous grains. No quartz could be found.

III. Fine Sand

Same composition as the preceding.

IV. Very Fine Sand

See microscopic study of parts.

V. Extra Fine Sand

Dirty green micaceous sand.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar=85 : 15
General appearance silvery-gray, micaceous.
The quartz grains are of two kinds:
(a) Glassy grains with more or less inclusions.
(b) Rough, pitted, granular fragments with a greenish tinge. The green-stained variety is, however, rare.
Glauconite occurs in pale, olive-green, transparent, rounded grains, very fresh looking.
All kinds of feldspars except plagioclases were noted, in general appearing rather rough and weathered but not kaolinized.

(2) Heavy

(a) Magnetic

General appearance light greenish-drab, with much muscovite and a striking absence of glauconite and generally of dark minerals.
Dominant.—Muscovite, chlorite, glauconite, serpentine.
Subsidiary.—Garnet, tourmaline, biotite, calcite (?).
The biotite appears much decomposed, some of it full of black grains (magnetite ?).

(b) Non-magnetic

Dominant.—Zircon.
Rare.—Enstatite, garnet, calcite, kyanite.

II. Extra Fine Sand

Appearance. Silver-gray with a greenish tinge.
(1) Much glauconite in round grains, green, semi-transparent, fresh-looking.
(2) Round, brownish grains specked with black. They look exactly like clay but polarize faintly. They differ from the glauconite in that the glauconite is clear without the black, granular inclusions. (Cf. Silt (III) below.) [1]

III. Silt

(1) Much *argillaceous* material in flakes or globules.
(2) Rounded grains of transparent, granular, *clay-like* material of which the globular form and aggregate polarization suggest that it may be incipient glauconite.
(3) Pale, yellowish-green, transparent glauconite.
(4) A few pale yellow, transparent, angular, granular, non-polarizing flakes, probably of limonite.
(5) Mineral grains are common.
(6) There are large flakes of mica.
(7) Black carbonaceous matter.

IV. Clay

Appearance blue-gray.
Pretty fine clay with much fibrous material which though dirty brown and clay-like in appearance yet polarizes.
The amorphous-looking clay also polarizes as an aggregate, probably on account of minute included mineral fragments. Individual mineral grains are, however, unusually scarce.

Summary and Conclusions.—Two characters are particularly striking in this sediment.

(1) The foremost is the abundance of mica apparent in the original specimen, but supplemented in the analysis by the high percentage of the

[1] Note that the clay was also found to have aggregate polarization though that may have been due to included mineral fragments.

fine-grained portions with which it goes in sedimentation, and the low proportion of heavy minerals, yet without a very high percentage of clay.

(2) The second important feature is the apparent secondary character of the glauconite. There are no botryoidal grains, all those that occur being rounded, and occurring only in the very fine-grained and finer portions.

Furthermore there is to be noted:

(3) The abundance of carbonaceous matter.

(4) The weathered condition of the feldspars.

(5) The abundance of biotite.

Of great general interest as bearing on the problem of the origin of glauconite are the rounded grains of substance having the appearance of clay and yet polarizing, suggesting a transition form between clay and glauconite. I shall take these up later in a general discussion of the glauconite below. (See p. 176, below).

SAMPLE NO. 5 (FIG. E, p. 169)

Serial number : 11.
Field number : 1-7-13-1911.
Formation : Matawan.
Locality : Chesapeake and Delaware Canal.
Appearance : Yellow, micaceous and slightly glauconitic sand.

MECHANICAL ANALYSIS

Sample	8.395 gm.
	Per cent of sample
Sands[1]	92.6
"Clay" (mainly yellow ocher)	7.7
Total	100.3
	Per cent of total sands
Coarse sand	0.2
Medium sand	2.8
Fine sand	24.9
Very fine sand	69.0
Extra fine sand	3.1
Total	100.0[1]
	Per cent of very find sand
Light	90.4
Heavy	8.6
Total	99.0

[1] Total sands by summation of parts.

MAGNETIC SEPARATION

	Per cent of total heavies
Attracted at 2000 ohms (glauconite)	52.2
Attracted at 1000 ohms	9.8
Attracted at 200 ohms (mica)	35.9
Total	97.9

Magnetite and non-magnetite each about 1 per cent.

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Eight grains of quartz, of which two are well rounded, the others fractured, more or less angular and rough. Here again it seems as if the roughness might in part be due to solution acting on the grains.

II. Medium Sand

Striking for the angularity of the quartz grains, though their surface is nevertheless glossy, again suggesting the action of solution. Yellowish-green glauconite with primary botryoidal form is present. There is some ocherous staining.

II. Fine Sand

In general the same as the medium sands with perhaps slightly more glauconite.

IV. Very Fine Sand

In this size the glauconite grains are in general worn, and there are many limonitic grains.

V. Extra Fine Sand

Very limonitic.

I. Very Fine Sand

I. Very Fine

(1) Light

Quartz : feldspar=90 : 10.

The grains of both quartz and feldspar have much glauconite adhering to their surfaces and penetrating into their fissures. There are some rusty, round grains of glauconite present.

(2) Heavy

(a) Attracted at 2000 Ohms

Mostly *glauconite* in rounded grains, some translucent brown, others semi-opaque, dirty, greenish-yellow.

Accessory.—Chlorite, epidote, tourmaline.

(b) Attracted at 1000 Ohms

Has a golden brown slightly green-tinged color, from an abundance of completely *yellow glauconite.*

Accessory.—Tourmaline, epidote, biotite.

(c) Attracted at 200 Ohms

Appearance golden-brown, micaceous. Almost all *biotite* generally pale yellow.

Accessory.—Serpentine, tourmaline.

(d) Full Current

Mainly mica and some enstatite.

(e) Non-magnetic

Most Common.—Enstatite.

Rarer.—Zircon, rutile.

Summary of Heavy Minerals

Dominant.—Glauconite, biotite.

Rarer.—Chlorite, epidote, muscovite, magnetite, tourmaline, serpentine, enstatite, zircon, rutile.

II. Clay

Very limonitic but also with a considerable fibrous portion.

Summary and Conclusions.—In spite of the fact that this is a rather pure sand with little clay the proportion of the finer sizes of sand, especially of the very fine, is remarkably large.

The proportion of *heavy minerals* is insignificant; for if from the small percentage that settled at 2.7 + is deducted the glauconite there remains principally biotite, which in spite of its specific gravity is not properly regarded as a heavy mineral.

The botryoidal form of the glauconite in this sample indicates that it has been formed in place. The large proportion of glauconite is unusual.

SAMPLE NO. 6 (FIG. F, p. 169)

Serial number : 12.
Field number : 2-7-13-1911.
Formation : Matawan.
Locality : Chesapeake and Delaware Canal.
Appearance : Typical Matawan of Maryland. A dark-gray, friable, fine-grained, somewhat argillaceous sand, showing glauconite under the hand lens.

MECHANICAL ANALYSIS

Sample	9.867 gm.
	Per cent of sample
Sands	75.4
Silt	2.2
Clay	21.2
Total	98.8
	Per cent of total sands
Coarse sand	1.7
Medium sand	9.3
Fine sand	32.6
Very fine sand	47.7
Extra fine sand	8.4
Total	99.7
	Per cent of very fine sand
Light	72.3
Heavy	26.3
Total	98.6

It was not at first intended to weigh the products of magnetic separation, so that a large amount of the glauconitic portion was taken out for various purposes before it was decided to weigh. From the weights of the other magnetic products, however, the weight of glauconite may be approximated:

Glauconite about 95% of heavy portion=about 25% of very fine sand.

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Contains one grain of fine gravel. Most of the quartz grains are milky, opaque, some of them stained green; doubtless by glauconite. A few of the grains are *perfectly rounded* and polished like wind-blown sand. The rest are subrounded or rough but many of them with the glossy "solution" surface. A grain of clay with included sand grains looks like a *concretion* (cf. Sample No. 3). Only one grain of quartz shows *limonitic staining*. There are some transparent, cellular, leaf-like plant fragments.

II. Medium Sand

Differs from the coarse sand:

(1) in containing a few grains of fresh-looking, green, botryoidal glauconite,

(2) in containing a very few grains of heavy minerals including a little mica.

III. Fine Sand

This portion has a "pepper and salt" appearance due to the abundance of glauconite mixed with the quartz. While most of the quartz is very angular there are, as in the preceding portions, still a number of very well rounded grains. Most of the glauconite is very fresh looking, but a good deal of it nevertheless shows rounding by wear.

IV. Very Fine Sand

Contains more glauconite than the preceding, but is otherwise very similar.

V. Extra Fine Sand

Dark greenish-gray, micaceous.

VI. Silt

Light greenish-gray, micaceous.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar=90 : 10.

The striking features are:

(a) The absence of limonitic staining.

(b) The small amount of glauconite along cleavage cracks and fissures.

(2) Heavy

(a) Attracted at 10,000 Ohms

As indicated above this is principally glauconite. The minerals identified are: garnet, tourmaline, deep blue chlorite, staurolite, epidote, muscovite, biotite, rutile.

(b) Attracted at Full Current

Dominant.—Muscovite, serpentine.

Common.—Tourmaline, rutile.

Rare.—Biotite, epidote, enstatite, quartz with rutile inclusions.

(c) Non-magnetic

Enstatite most common with much zircon.

II. Extra Fine Sand

The glauconite in this portion is in rounded grains.

III. Silt

Here the glauconite is in irregular flakes. The product therefore has a distinct qualitative though not a quantitative significance.

IV. Clay

A normal, pure-looking, blue-gray clay showing under the microscope few mineral grains. but also few of the polarizing fibrous particles which appear to be characteristic of most of the clays; it is mainly amorphous brown matter.

Summary and Conclusions.—This is a typical, normal sample of the Matawan of this region and as such offers little requiring special comment here. The condition of the glauconite in it seems to prove that the glauconite is primary, so that this sediment represents lithologic conditions under which glauconite may be formed. There has been very little secondary action of any kind as is proved by the absence of limonitic and of glauconitic staining, while the sharpness with which the separation of clay and sand could be made confirms this conclusion.

The seeming argillaceous concretions (see coarse and medium-grained sand) should be noted. Noteworthy, also, is the small amount of carbonaceous matter.

SAMPLES NOS. 3, 4, 5, AND 6

General Summary and Conclusions.—These four samples are from one locality and section and were taken in order to find what the analyses might show to supplement their field relations. The results are interesting enough to justify a special discussion here.

Following is the field section, beginning at the top:

	Feet.
(5) A capping of post-Cretaceous gravel and diagonally (current) bedded sand.	
(4) Very glauconitic, yellow, somewhat argillaceous sand............	2–3
Sharp contact with	
(3) Very glauconitic, gray, argillaceous sand (Sample 6)............	6
Bed 3 seems to grade into bed 2 although an appearance of a sharp contact is given by a thin line of limonitic staining separating the two beds.	
(2) A light yellow, glauconitic sand containing little clay in the upper part but growing more argillaceous and gray towards the bottom (Sample 5)..	12
About 2 feet at the top are filled with tubes ¼ inch in diameter, running through the sand in all directions and containing very glauconitic sand.	
Sharp contact with	
(1) A dark gray, micaceous, glauconitic, argillaceous sand, growing less micaceous and more glauconitic towards the lower part. Exposed to base of section....................................	5
(Sample 4 = upper micaceous part.)	
(Sample 3 = lower glauconitic part.)	

Considering the field section and the analyses together we find that they fall very naturally into two distinct types.

A. That represented by samples 3 and 4 = bed 1; micaceous material, with reworked glauconite and much carbonaceous material.

B. That represented by samples 5 and 6 = beds 2 and 3; typical Matawan beds, with glauconite evidently formed in place.

The resemblance of type A to the Magothy as at Betterton (see samples 1 and 2) is apparent, with the marked difference, however, that there is here no rapid alternation vertically in the character of the beds. Without paleontological evidence it is moreover not certain that bed 1 here is not Magothy, though just as there was evidently glauconite formed before the formation of the similar beds of the Magothy at Betterton, so there is no apparent reason why in the midst of the glauconite formation of the Matawan there should not be a facies similar to the Magothy.

While the present state of our knowledge of sediments does not allow a definite classification of these beds, I think it is evident that bed 1 represents more of the river delta type of deposit while beds 2, 3 and 4 represent the more quiet conditions under which glauconite is formed.

Considering these two groups we find at first glance a remarkable lack of difference in the relative proportion of sand and clay and in the percentage of very fine sand, but the striking difference is in the distribution of the other sizes. Thus in what are tentatively called the delta type there is very little material coarser than the very fine; this portion forming the maximum and appearing in the diagrams (figs. C, D, p. 169) with the abruptness characteristic of delta and stream sediments (*cf.* figs. D, I, J, p. 170); at the same time the abundant extra fine gives a transition to the clay--a feature which from these same diagrams on p. 170 is seen to belong more to this type of sediments.

Samples 5 and 6 (E, F, p. 169) on the other hand, while they show some marked differences from each other, have in common a clear antithesis to samples 3 and 4 in the two features just enumerated, that is, there is a more gradual gradation through the coarser sizes to the maximum in the

very fine, and a more sudden drop to the fine, features which from the diagrams on p. 170 are seen to differentiate open-water sediments from those of deltas or streams (compare figs. A, C, E, with D, I, J, p. 170).

Furthermore, while at first sight the proportion of heavy minerals shows no consistent difference in the two groups, it is found when glauconite is deducted that the percentage of heavy minerals in the glauconitic type is only 2%-3%, while in the "delta" type it is about 8%. Besides, the deduction of glauconite is much more significant in the glauconitic type, since here it is not an imported mineral. But while in its fresh condition glauconite has generally a specific gravity considerably less than 2.7, it is questionable whether the material in bed 1 had not already become partly decomposed, and thus actually a heavy mineral, before it was transported into bed 1. In sample 3, which is the portion of bed 1 in which glauconite is particularly amundant, both the glauconite itself and the ocherous staining of other minerals support this belief, as I have indicated in the discussion of that sample.

As to the history of the succession that can now be worked out for this section I should first question the field determination of a sharp contact between beds 1 and 2. On the contrary, since bed 1 is very argillaceous, and bed 2, while it grows more sandy towards the top, is also argillaceous at its base, it seems more probable that there was here a transition, though it may have been quite sudden.

Then we have in bed 1 the evidence for the exposure of an older glauconitic bed to the atmosphere with partial decomposition of the glauconite and ocherous staining of the other grains. This bed was attacked by the stream which deposited in its delta the material of bed 1, while through deepening of the water or reduction in grade of the supplying stream the material gradually grew finer. Ultimately by a continuation of this evolution the waters became quiet and clear, and favorable to the formation of glauconite. Under these circumstances beds 2 and 3 (samples 5 and 6) were formed, but the conditions controlling were, at noted above, not in all respects similar for the two beds. A glance at E and F, p. 169, and comparison with the figures on p. 170 show at once the essential grouping of

the differences. Bed 2 (sample 5, fig. E, p. 169) is of the well-sorted type produced by strong wave action or by wind; bed 3 (sample 6, fig. F, p. 169) shows a remarkable resemblance to the poorly-sorted lagoonal type represented in E, p. 170.

The facies of bed 3 (sample 6) is therefore easily recognized; it was formed not in the open sea but in a more enclosed body of water, a lagoon, or perhaps an estuary or an arm of a bay like Chesapeake Bay of to-day. But bed 2 (sample 5) is harder to place. Mere comparison of its diagram (E, p. 169) with the diagrams on p. 170 shows a resemblance to diagram J even more striking than that of F, p. 169, to E, p. 170. This does not necessarily mean that bed 2 was wind-deposited. Its general conforming to the rest of the section with transition probably at bottom as well as at top (in any case a more argillaceous composition in its lower part), and the fact that no striking rounding of the quartz grains was noted, are against this interpretation. The discrepancies can be adjusted if it be assumed that the difference between diagrams of wave-sorted material, like C, p. 170, and wind-sorted material like J, p. 170, is more fundamental than mere difference between action of water and air, and represents rather the different effects of wave and current action. That is, a current of water might produce the same sorting shown in E, p. 169, as was produced in J, p. 170, by a current of air.

Theoretical considerations lend support to this conclusion. For the action of waves consists essentially in a prolonged *working over* of material of a certain maximum degree of coarseness depending on the average uniform conditions under which material is supplied to them. From this they tend to eliminate all the finer material, producing a concentration of the coarsest. Even though their strength is constantly fluctuating the end result of their work is the product essentially of their *maximum force.* But a current is an actively *depositing* agent, and while it will also tend to eliminate all material that is fine enough to be carried by it, the sorting it produces will be rather the result of its *mean* strength corresponding to a certain fineness of material which would be accumulated too fast to be accessible for reworking by its maximum strength. Hence the coarsest material brought in during periods of maximum

strength would represent a minor admixture to a larger quantity of its average size. In this way would result the difference between marine and wind sediments shown by diagrams C and J, p. 170, in that in the marine deposits, which are essentially the products of wave action, the next largest quantity after the maximum is in the next finest material, while in dune sands, which are essentially current-deposits, it is in the next coarsest. That is to say, in wave-worked material there would be an admixture of finer material which had escaped the maximum wave strength, while in current-deposits the products of their greatest strength would appear as the admixture and the finer material produced by their average strength would survive as the maximum.

That some sorting action and not the advent of coarser material is responsible for the presence of a smaller amount of very fine sand in bed 3 (sample 6, F, p. 169) than in bed 2 (sample 5, E, p. 169) appears from the fact that there is actually more of coarse, medium, and fine sand together in the argillaceous sample 6 than in the sandy sample 5. It may still be, in view of our imperfect knowledge of the mechanical composition of sediments, that in spite of the divergence of sample 5 from typical wave-worked sediments it is nevertheless the product of deposition in more open water, perhaps as a result of the deepening suggested above, and that as deposition continued, or possibly uplift of the region replaced subsidence, the area in which this section was deposited became cut off as a lagoon or estuary. But the interpretation that the difference is due to a local current which passed over the area when the lower bed (bed 2) was being deposited, but disappeared before the deposition of the upper bed (bed 3), seems the more probable.

The position of the line of limonite staining between beds 2 and 3 is probably determined by distance from the surface and porosity combined. Such lines are common throughout the region and by their wavy form and lack of relation to the lithology show that they are secondary and formed by circulating ground waters.

Bed 4 may represent shallowing of the water, but as it is at the top of the section its sandy yellow appearance is more probably due to alteration, so that in the absence of an analysis nothing definite can be said about it.

SAMPLE NO. 7 (FIG. G, p. 169)

Serial number : 15.
Field number : 3-9-12-1911.
Formation : Matawan.
Locality : Camp Fox, Chesapeake and Delaware Canal.
Appearance : Friable, sandy, gray-white marl, speckled with glauconite.

MECHANICAL ANALYSIS

Sample .... 8.404 gm.

Treated with dilute HCl to dissolve lime.

	Per cent of sample
Lime-free residue	80.2
Lime (by difference)	19.8
Total	100.0

	Per cent of lime-free residue
Sands	87.8
Silt	0.9
Clay (by difference)	11.3
Total	100.0

	Per cent of total sands
Coarse sand	0.2
Medium sand	16.2
Fine sand	60.6
Very fine sand	20.0
Extra fine sand	2.8
Total	99.8

	Per cent of very fine sand
Light	57.3
Heavy	42.2
Total	99.5

MAGNETIC SEPARATION

	Per cent of total heavies	
Attracted at 2000 ohms (glauconite)	86.0	=36.2% of very fine
Attracted at full current	7.5	= 6% of very fine
Non-magnetic	0.4	
Magnetite	3.0	
Total	96.9	

	Per cent of 2000-ohms portion.
Attracted at 2000 ohms, S. G. > 3.002	13.9
Attracted at 2000 ohms, S. G. < 3.002 (glauconite)[1]	86.1 = 74.0% of heavy = 31.2% of very fine
Total	100.0

[1] A minimum value for glauconite in this portion, since some glauconite came down with the part heavier than 3.002. There are, on the other hand, some heavy minerals especially mica in the part that floated at 3.002 though their weight is doubtless less than that of the glauconite that settled. Good approximations are probably :
Glauconite 80% of heavy = 35% of very fine,
which leaves actual *heavy minerals* about 7% of the very fine.

DESCRIPTION OF THE PRODUCTS

A. UNDER THE HAND LENS

I. Lime-free Residue

This separates in water into two very distinct parts:

(1) Very glauconitic clear sands.

(2) Dark brown clay (probably with considerable limonite) which floats on top.

II. Coarse Sand

Eight grains of quartz with glossy, pitted surfaces; one of them is stained green; one is sugary and stained brown. Some leaf fragments.

III. Medium Sand

Glossy, angular quartz; some sugary grains stained brown as in II; almost no grains stained green. Very fresh botryoidal glauconite; some rounded grains of glauconite.

IV. Fine Sand

Much of the glauconite is rounded and more than in III is faded yellowish; otherwise the glauconite is as in III. There is very little mica.

V. Very Fine Sand

The glauconite is almost all rounded, much of it weathered yellowish. The grains of quartz are all angular.

VI. Extra Fine Sand

General appearance green. The glauconite is half yellowish, half fresh, blue-green.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar = 90 : 10.

The determination of the proportion of feldspars present is made difficult by the presence of minerals in various stages of decomposition, towards a mass with complex aggregate polarization, which may be derived from feldspars. Difficulties are also afforded by cloudy grains which may be quartzite. Most of the feldspars are much weathered. A grain of plagioclase was noted. There is much irregular glauconitic staining of grains, and glauconite in thick seams along cleavage cracks. Many grains of glauconite are present.

(2) Heavy

(a) Attracted at 2000 Ohms, S. G. > 3.002

More than half *glauconite*. *Magnetite* largest part of remainder, many of the grains well rounded. *Red garnet* a little less common than magnetite. Epidote and staurolite rather common. Some chlorite. Green zircon (?).

(b) Attracted at 2000 Ohms, S. G. < 3.002

Almost pure *glauconite*, in well rounded or botryoidal grains, opaque to slightly translucent, free from coarse-granular inclusions. The botryoidal grains are very scarce. There is, in addition, a very little muscovite and quartz.

(c) Attracted at Full Current

Tourmaline, rutile, augite, biotite, muscovite, green zircon, chlorite, glauconite. The *glauconite* in this portion is in rough, irregular grains, cloudy to opaque, mostly full of black mineral grains. Many of the grains that look like *chlorite* are found to have undulatory to aggregate polarization indicating that they are in a transition stage from or to chlorite. In view of the fact that glauconite is itself believed to be one of the chlorites this may be of significance for the formation of glauconite. Two small, remarkably *spherical* grains of *quartz* are noteworthy.

(d) Non-magnetic

Most common enstatite, zircon, augite, hornblende, apatite, rutile, andalusite (?). The good preservation of the crystal form of the rutile is striking.

(e) Magnetite

Very angular, with a few rounded grains. Much glauconite included. Some garnet.

II. Extra Fine Sand

Largely *glauconite* in *irregular* grains.

III. Silt

Nothing of interest. Mineral grains, much mica, glauconite. Very few limonite flakes.

Summary and Conclusions.—This sample, which may be considered typical of the facies of the Matawan in this neighborhood, is interesting, first of all for its marly character, that is for the combination in it of clay and high lime content with glauconite. With the high lime content goes a great richness in fossils. I can see no reason for considering this difference other than primary, since there is no factor apparent that would preserve the lime here more than in other occurrences. Of course it is assumed that foraminifera originally occurred in all the primary glauconitic rocks, but their shells would form merely a thin coating on the individual glauconitic grains, not a calcareous argillaceous mass through which the glauconite might be distributed. It is, therefore, fair to assume that the bed was formed under conditions unusually favorable to the life of neritic shell bearing forms.

The diagram for the sample (K, p. 169) is that of a rather normal open-water off-shore sediment, with sorting, however, less perfect than in marine off-shore deposits.

In the mineral composition there is noteworthy the occurrence of several minerals scarce or very rare in other samples, especially hornblende, augite, apatite, and andalusite. The unusually good preservation of the crystal form of rutile indicates its derivation from nearby.

The general fresh condition of the glauconite is characteristic for the sample. In view of this fact it does not seem probable that the irregular grains of glauconite with inclusions represent a decomposition product, for in that case some intermediate stages would be expected. More probably, therefore, they are a distinct type of glauconitic product. Their form and ocurrence suggest analogies with the limonitic flakes in many samples, which are probably mainly small encrustations loosened from the grains on which they occur. In the same way these would be loosened flakes of glauconite encrustations, such as are found on the surface and in

cracks of many quartz and feldspar grains in this and other samples. While the botryoidal grains of glauconite were presumably formed in the shells of foraminifera, these encrustations and stains must have been formed unenclosed in the midst of the sediment. Though the manner of their formation is not yet clear this difference in the conditions under which they developed may well account for their different appearance.

Concerning the complex chloritic grains, also in the full-current product, I have no interpretation to suggest, but merely draw attention to them again here.

SAMPLE NO. 8 (FIG. H, p. 169)

Serial number : 16.
Field number : 5-9-12-1911.
Formation : Matawan or Monmouth.
Locality : Camp Fox, Chesapeake and Delaware Canal.
Appearance : Fine-grained, dark-green, speckled sand, considerably weathered and stained with limonite.

MECHANICAL ANALYSIS

Sample	7.700 gm.
	Per cent of sample
Sands	88.8
Silt	0.6
Clay	11.1
Total	100.5
	Per cent of total sands
Coarse sand	0.5
Medium sand	27.2
Fine sand	42.8
Very fine sand	26.3
Extra fine sand	2.9
Total	99.7
	Per cent of very fine saud
Light	63.2
Heavy	36.5
Total	99.7

MAGNETIC SEPARATION	Per cent of total heavies
Attracted at 1500 ohms	90.5
Attracted at full current	4.4
Non-magnetic	0.2
Magnetite	1.8
Total	96.9

	Per cent of 1500-ohms portion	
Attracted at 1500 ohms, S. G.>3.002	6.2	
Attracted at 1500 ohms, S. G.<3.002 (glauconite)	94.8	=85.8% of heavy=31.3% of very fine
Total	101.0	

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Quartz grains so strongly pitted that their original form is obscured. Many of them are stained yellow. Besides the quartz there are brown, opaque, limonitic grains. One of these has the characteristic form of an agglomerated glauconite grain. There are two little concretions of sand, one in a dark blackish matrix, the other in a yellow, limonitic cement like the concretions in sample 3.

II. Medium Sand

Yellowish-green, specked with dark glauconite. The quartz is angular. Glauconite botryoidal. Smooth reddish-brown grains of which one or two were seen in the coarse sand are more common here. Some of them have a conchoidal fracture like limestone, and the fresh surface is pinkish-white. Others, probably partly decomposed, are brittle and pale yellow inside. They dissolve with effervescence in cold dilute hydrochloric acid. They are therefore probably either siderite, or calcite or aragonite stained by limonite. Their smooth rounded form and glossy surface suggest their origin in connection with some organic process.

III. Fine Sand

Like II except that there appears to be somewhat more glauconite and that most of the glauconite is in rounded grains.

IV. Very Fine Sand

Like preceding but much of the glauconite turned yellow.

B. UNDER THE MICROSCOPE

I. Light

Quartz : feldspar=90 : 10.

General appearance greenish with some grains of glauconite and some limonitic stain. There is much glauconite along the cleavage of feldspars and in irregular staining patches on the outside of the grains. Some of the glauconite grains seem to show almost their original botryoidal form.

II. Heavy

(1) Attracted at 1500 Ohms, S. G. >3.002

Dominant.—Magnetite, garnet (red and colorless), epidote, staurolite.
Rarer.—Tourmaline, chlorite, chloritoid (1 grain).

(2) Attracted at 1500 Ohms, S. G. <3.002

Practically pure glauconite. Opaque and densely clouded grains with a yellowish tinge. They do not show coarse granular inclusions only a fine disseminated powder responsible, at least in part, for the cloudiness.

(3) Attracted at Full Current

Under the hand lens much rusted glauconite and other rust-colored minerals. Chlorite, muscovite, biotite, tourmaline, andalusite, augite, apatite, rutile, enstatite, zircon, kyanite, aragonite. Particularly characteristic are two types of grains to which the brown color of the portion is largely due. These are:

(a) A brown granular, non-polarizing grain which looks like what I have been calling limonite but which dissolves completely in dilute acid, with strong effervescence.

(b) A brown, translucent mineral occurring in irregular forms but also in parallel sided (prismatic) grains. The grains of irregular shape have imperfect, more or less undulatory extinction, but that of the prismatic grains is generally perfect and parallel. These grains also dissolve with effervescence in dilute acid, but seemingly not always completely, leaving a skeleton or nucleus.

The only explanation I have for (b) is that it is aragonite stained with limonite. The form and undulatory extinction of some of the fragments of this type suggest that they are parts of the shells of some animal—(a) is probably something similar, but I cannot explain its non-polarizing. The matter requires further study. Most of the flakes of mica and grains of decomposed minerals in this portion are stained green.

(4) Non-magnetic

Dominant.—Zircon, enstatite, apatite, in about equal amounts.
Rare.—Kyanite, rutile.

(5) Magnetite

Almost all in angular grains. Contains, besides, much slightly cloudy, yellowish-green glauconite. Some muscovite and garnet.

III. Extra Fine Sand

General appearance drab olive-green. Light minerals and glauconite in about equal proportions, with of course some rare minerals. The glauconite is both in rounded grains and in irregular fragments. There are some limonitic flakes.

IV. Silt

Limonitic flakes are prominent in this portion. There is less glauconite than in the extra fine-grained.

V. Clay

General appearance faint yellowish-gray, with not as much limonitic material as might be expected from the character of the rock. There is a considerable amount of the fibrous material which has been found characteristic of the clays.

SAMPLES NOS. 7 AND 8

General Summary and Conclusions.—The significance of sample 8 is largely in its relation to sample 7, so that it must first of all be considered in connection with this.

In the field the upper part of the marly glauconite sand from which sample 7 is taken was found to be full of pycnodont shells much worn, bored, and sometimes broken. This condition seems to indicate a period of exposure in shallow coastal water. Together with the sharp contact between this bed and the overlying, it proves a disconformity, at least locally.

The most striking fact about their relations is the almost perfect similarity in every respect except the lime content.

The sands in the upper bed (sample 7, fig. L, p. 169) are a little coarser and a little less perfectly sorted, but in the proportions of sand and clay, the general relation of the different sizes and the mineral content there is remarkable agreement. This extends even to the proportion of glauconite, which is almost exactly the same in the two beds. The only

difference is a secondary one that might be expected from the loose texture of the upper bed as against the compactness of the lower—namely, more limonitic matter in the upper. But it is very interesting to note that the glauconitic staining of mineral grains is not one of these secondary differences; nor the apparently altered opaque condition of the glauconite; which would thus seem to have been produced before the beds were emerged.

The two beds are thus so intimately related that if it were not for the accumulation of oysters in the top of the lower bed one would be led to assume continuous deposition. The essential difference is in the presence of abundant shells in the lower bed. It may be that the somewhat less agitated condition of the water in which the upper bed was deposited produced enough difference to make the area relatively unfavorable for the animal life which had abounded at the time the lower bed was formed. In any case the change appears to have been a subtle one.

SAMPLE NO. 9 (FIG. I, p. 169)

Serial number : 19.
Field number : 17-9-28-1911.
Formation : Matawan.
Locality : Grove Point, mouth of Sassafras River.
Appearance : Dark blackish-gray, fine-grained, micaceous, argillaceous sand with some scattered pebbles of fine-grained white quartz too scarce to have been caught in analysis.

MECHANICAL ANALYSIS

Sample	10.780 gm.
	Per cent of sample
Sands	68.5
Silt	2.1
Clay	28.2
Total	98.8
	Per cent of total sands
Coarse sand	0.1
Medium sand	0.4
Fine sand	0.5
Very fine sand	45.1
Extra fine sand	53.0
Total	99.1
	Per cent of very fine sand
Light	91.4
Heavy	5.6
Total	97.0

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Nine grains of milky quartz, some very rough, others rounded but strongly coroded. Several black carbonaceous flakes.

II. Medium Sand

Much like the coarse sand, with some glossy quartz in small angular grains, with more well rounded grains than the coarse sand, some mica, and much black carbonaceous matter mainly fragments of wood.

III. Fine Sand

Very much white mica and some chlorite. Most of the quartz is sharply angular but there are still some rounded grains. There are a few grains of heavy minerals, zircon, garnet, etc. Very much black carbonaceous matter as above.

IV. Very Fine Sand

Silver-gray with much mica and much fine carbonaceous matter. It is darker than the extra fine sand which apparently contains little carbonaceous matter.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar=95+ : 5—.

It is hard to count the feldspars in this sample on account of the aggregate polarization of many grains which probably are decomposing feldspars but which cannot be identified. However, this should be regarded as an essential character of the rock and with the low percentage of feldspar shows that the *decay of the feldspars* had advanced far in this sample.

There is a great variety of feldspars present including some plagioclase.

The material is characterized by a dirty yellowish staining of the grains neither ocherous nor glauconitic but in a very few cases looking like remnants of a glauconitic stain. There are a few chloritic grains which, however, show aggregate, incomplete, or undulatory polarization, and some very pale greenish-yellow without noticeable birefringence.

There is considerable muscovite. No glauconite was found.

(2) Heavy[1]

(a) Magnetic

Dominantly muscovite with abundant chlorite and biotite. A very little garnet and tourmaline were found.

(b) Non-magnetic

Zircon.

II. Extra Fine Sand

Fine grayish-white sand. Quite pure, unstained quartz and feldspar with some scattered carbon and a few grains of green chlorite in evidence.

III. Silt

Darker gray, more micaceous than II. Under the microscope like the extra fine sand with more carbonaceous matter and more mica. There are many of the pale yellow chloritic grains that were observed in the very fine light portion.

IV. Clay

Pure blue-gray. Unusually rich in the fibrous, dirty-colored, polarizing material found so characteristic of the clays.

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[1] This was the first sample examined for minerals so that the identification is probably not complete.

Summary and Conclusion.—The prominence of fine-grained material in the sample and the abundant mica and carbonaceous matter recall the Magothy formation of this region, but it differs from the Magothy in the field by occurring in massive beds, while the Magothy is thin-bedded or laminated. Moreover, there are marked differences in the composition of the material. Its diagram (G, p. 169) is peculiar in that while it shows almost only fine material the nearly equal proportion of the different sizes is striking. The abrupt rise of the "curve" on the right is a character, as already noted, of stream sediments, but the stream sediments shown in diagram M, p. 170, do not show so large an admixture of clay to sands. In the study of this bed in the field a peculiar mottled effect of light and dark-gray portions, which on close examination were found generally to consist of cylindrical tubes of the light sand running at random in more or less vertical directions through a matrix of the dark sand, was noted. They did not resemble worn tubes which are generally solid cylinders, not, like these, hollow cylinders filled with the dark material that surrounds them. The interpretation which suggested itself at the time was that the sand had been deposited in the midst of reeds which after their decay had been replaced by clay but had bleached the sand around them. I think this clue leads to a diagram which while not exactly like G, p. 169, yet explains some of its anomalies. On p. 170 are two diagrams, G and H, of materials from the same general lithologic belt in the Lagoon of Thau, but H representing sediment deposited in a portion of the lagoon overgrown with water plants. The effect of such a tangle of plants would naturally be to produce less perfect sorting, and this is what we see in comparing diagrams G and H, p. 170, the extra fine portion having been increased at the expense of the clay but without an increase, even with a slight decrease, in the relative amounts of the portions coarser than extra fine. This low proportion of these coarser sizes would naturally result from their interception in the same way by the nearer-shore portions of the same plant areas. As a result of these processes then, a diagram like I, p. 169, though of the general lagoonal type, comes to resemble more specifically diagram H, p. 170, the extra fine sand and a part of the clay having been

increased by the holding action of a plant tangle so as to equalize their amount more with that of the very fine sand.

Combining this conclusion with the stream character indicated by the sharp rise of the "curve" on the left we have here a sediment deposited where a stream discharged into or flowed through the midst of plants in some small quiet body of water. Regarding the grains of quartz in the coarser sizes it should be borne in mind, not only for this sample but for all others, that there is always the possibility, especially in near-shore deposits such as these, that they have been brought in by wind. Thoulet[1] has shown the transporting power of wind, a strong gale (13 m. per sec.) being able to carry grains over 1 mm. in diameter, and, while these theoretical deductions are somewhat invalidated by Udden's[2] observations on wind deposits and his theoretical deduction that the effective force of the wind is only that which survives the friction of the earth's surface (probably never exceeding 3 miles an hour), it is yet indicated by observation[3] as well as theory that an occasional coarse grain is brought in by winds. This agent therefore may well be accountable for the few grains even of the coarsest size found in this sample; that a current which transports material so very predominantly of the finest sizes should ever bring in these few scattered coarse grains seems very improbable, while it is reasonable to believe that an occasional strong wind would be quite able to supply them.

The rounding of these grains which, as noted above, is a marked characteristic of many of the grains of the fine sand is a feature more common in wind-blown than in water-transported sand, and therefore also lends support to this conclusion.

There is another feature of the sample, however, which is perhaps of even greater stratigraphic interest than the evidence of the conditions of its deposition. That is, the indications of weathering which its material bears, and the absence of glauconite. Since other deposits of this type

[1] Thoulet, J., Analyse d'une poussière éolienne de Monaco, etc. Annales de l'Inst. Océanograph. Tome iii, Fasc. 2, Paris, 1911, 8 pp.

[2] Udden, J. A., Op. cit.

[3] See Thoulet's observations, in the paper just cited, on sediments off the Azores supposed to have been brought by wind from the Desert of Sahara.

have been studied and the material in them not found so weathered it is justifiable to conclude that the sands of this sample were weathered before they entered the bed. This would presumably be the interval corresponding to a disconformity between the Magothy and Matawan during which sedimentary beds from which this material was derived were exposed to atmospheric weathering. The absence of glauconite also tends to confirm this belief, for while the beds contributing it to the Magothy (in which it is all reworked) might have just become exhausted with the closing of the Magothy, it is very improbable that the two phenomena would so closely agree in time, and much more probable that there had been a considerable interval during which either the glauconitic beds were completely eroded, or the glauconite entirely decomposed.

SAMPLE NO. 10 (FIG. J, p. 169)

Serial number : 4.
Field number : 4-9-28-1911.
Formation : Matawan just below the contact with the Monmouth, or basal Monmouth.
Locality : Sassafras River.
Appearance : A greenish-yellow, lumpy, crumbly sand, full of limonite spots and with some tinges of a lavender-brown clay. Under the hand lens it shows rather angular quartz sand with small, rusty grains of glauconite; and throughout the mass, but seemingly related to the glauconite, an epidote-colored stain. On a freshly-broken surface the lavender-brown argillaceous matter is evident.

MECHANICAL ANALYSIS

Sample for gravel[1]	205.075 gm.
	Per cent of sample
Medium gravel	0.4
Fine gravel	1.6
Sands	98.0
Total	100.0[1]
Sample for sands and clay	10.236 gm.
	Per cent of sample
Sands[2]	62.1
Silt	3.7
Clay	24.1
Total	89.9
	Per cent of total sands
Coarse sand	1.1
Medium sand	37.6
Fine sand	43.6
Very fine sand	14.2
Extra fine sand	3.5
Total	100.0[2]

[1] By summation of parts.
[2] Total sands by summation of parts.

	Per cent of very fine sand
Light	94.6
Heavy	5.4
Total	100.0

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Grains of glassy quartz and some opaque, subrounded but showing a glossy, pitted surface as if solution had acted on them. The opaque grains, which are probably a saccharoidal quartz of quartzitic origin, are penetrated by an ocherous stain of which there are traces on some of the other grains. There are almost no grains that look as if they had been well rounded before solution acted on them.

II. Medium Sand

Much like the coarse, but there seems to be a somewhat larger number of rounded grains in it.

III. Fine Sand

Like preceding.

B. UNDER THE MICROSCOPE

I. Very Fine

(1) Light

Quartz : feldspar=90 : 10.

The feldspars are striking for the predominance of fresh grains (probably mostly sanidine) among them. Feldspars showing the characteristic kaolonization along cleavage cracks are very rare. Some were observed that had small bands of glauconite arranged along cleavage cracks.

(2) Heavy

Among the heavy minerals glauconite generally in weathered, brown, opaque grains is the most common.

Common.—Magnetite unusually abundant; garnet very common; epidote.

Rarer.—Tourmaline, chlorite, staurolite, rutile, zircon, enstatite, kyanite. Striking in this rock are the varieties of zircon; besides the usual colorless to pale hyacinth there are grass-green and smoke-brown zircons.

II Silt

The silt in this case differs markedly from the very fine sand in that much of the limonite present has gone into the silt, while the very fine sand is made up mostly of fresh primary mineral grains.

III Clay

The product called clay is here, as in all samples in which much limonite has been formed by weathering, a very impure product containing, in addition to true primary matter, much of this secondary limonite.

Summary and Conclusions.—The principal features of this sample are:

(1) The prominence of the coarser sizes of sand and the marked lack of sorting. The diagram (I, p. 169) is distinctly of the lagoonal type (*cf.* A, p. 169, and E, p. 170) and therefore requires no special comment. It may well represent the basal deposit of a transgressing estuary of a large bay like Chesapeake Bay, or of a lagoonal body of water.

(2) The lack of rounding of the sand.

(3) The very small proportion of heavy minerals.

(4) The relative abundance of magnetite and garnet in the heavy portions, a character which seems to be correlated with coarseness and poor sorting.

(5) The scarcity of mica.

(6) The reworked glauconite.

(7) The freshness of the feldspars.

This bed differs markedly from most occurrences of Matawan mainly in the coarseness of its grain, and in the absence of black clay. It occurs in the following section as recorded in the field, beginning at the top:

5. Monmouth glauconite sand penetrated by limonitic crusts.
4. A marked ¼ inch limonitic crust separating 5 from
3. A sandy transition zone (sample 10) to
2. Argillaceous Matawan with finely disseminated limonitic crusts.
1. Fresh argillaceous Matawan.

In the absence of analyses of the underlying and overlying beds this sample loses much of its significance, yet the field relations, and general knowledge of the two formations between which it lies, in conjunction with its own analysis, seem to point pretty clearly to its interpretation. The author is then inclined to regard it rather as a basal part of the Monmouth reworked from the underlying Matawan than as upper Matawan. The general coarseness of the material (which is of the character of a basal bed), the reworked condition of the glauconite, and the weathered condition of the upper part of the Matawan, as shown by the limonite crusts in bed 2, support this view. The distinction is rather essential. If the bed belonged to the Matawan it would represent a gradual shallowing, forming a transition to the coarser sediments of the Monmouth. By the other interpretation there was an interval after Matawan time during which the upper part of the Matawan was weathered, then a transgression of the Monmouth which accumulated a basal layer of coarse material and *reworked glauconite* before the typical Monmouth conditions with the formation of primary glauconite were reached.

SAMPLE NO. 11 (FIG. K, p. 169)

Serial number : 18.
Field number : 5-10-28-1911.
Formation : Monmouth.
Locality : Seat Pleasant, Prince George's County, east of D. C. Line.
Appearance : A fairly light gray-black, fine-grained, very micaceous, argillaceous sand, with many shells and shell fragments. This is one of the good fossil localities of the Matawan.

MECHANICAL ANALYSIS

Sample .... 7.185 gm.

Treated with dilute hydrochloric acid.

	Per cent of sample
Lime-free residue	94.8
Lime (by difference)	5.2
Total	100.00

	Per cent of lime-free residue
Sands	80.7
Clay	18.9
Total	99.6

	Per cent of total sands
Coarse sand	0.3
Medium sand	2.6
Fine sand	5.1
Very fine sand	60.9
Extra fine sand	30.0
Total	98.9

	Per cent of very fine sand
Light	93.3
Heavy	6.9
Total	100.2

MAGNETIC SEPARATION

Attracted at 3000 ohms (mainly glauconite)	4.3 [1]
Attracted at 1000 ohms (mainly glauconite)	36.9 [1]
Attracted at full current	13.0
Non-magnetic	28.7 [2]
Magnetite	17.4 [3]
Total	100.3

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Course Sand

(a) Three grains subangular to very well rounded, frosted.

(b) Four grains likewise rounded but glossy and slightly pitted as though corroded by solution.

(c) Four grains rough, pitted, *angular,* corroded, with much greenish-black clay in the irregularities of the surfaces. This shows a transition from (b), suggesting that most of the grains were originally rounded. (a), (b) and (c) are of glassy quartz.

(d) *Sugary* quartz, rough, fissured, pitted and filled with green *glauconitic* and black clay *stain*. Four grains.

---

[1] Glauconite (see microscopic study below) may be taken about 37.5% of heavy=2.5% of very fine.
[2] Mainly carbonaceous matter.
[3] Note the unusually high magnetite.

(e) Three very dark grains apparently filled with black clay and green glauconite stain. These are like the grains in sample 13 which are believed to be *secondary* quartz. Under the microscope these grains show homogeneous polarization and much of the included matter appears to be mica.

II. Medium Sand

Mainly like the coarse with the following differences:

(a) The smaller grains instead of being rounded, are sharp, fresh, *angular*, evidently primarily so. Rounded grains are, however, still very abundant.

(b) Dark minerals (mainly magnetite and mica) begin to appear.

(c) There are more of the stained quartz grains.

III. Fine Sand

Characterized:

(a) By the appearance of rather abundant, rounded, yellow-green *glauconite* grains.

(b) By the *angularity* of the quartz.

(c) By the freshness of the quartz, *i. e.*, little stained sugary quartz and *no secondary* grains with clay inclusions were observed.

(d) By the abundance of carbonaceous fragments.

(e) By the fact that there appears to be little, if any, increase in the proportion of dark minerals, except glauconite.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Greenish-gray with much mica.

Quartz : feldspar=95 : 5.

No distinct secondary quartz or feldspar with black clay inclusions, though black clay has penetrated into the fissures of a few grains, especially of feldspar. Glauconite staining occurs but is not abundant. There is no limonitic staining. There are here, as in sample 4, some of the rounded, clay-like grains showing a faint aggregate polarization, apparently transition forms to glauconite. Glauconite in rounded grains mostly full of round black granules.

(2) Heavy

The heavy minerals are:

Glauconite, chlorite, muscovite, epidote, tourmaline, garnet, amphibole (colorless), staurolite, zoisite, rutile, serpentine, enstatite, zircon, kyanite.

The glauconite is full of black granules. The chlorite and muscovite are in the same condition.

II. Extra Fine Sand

Dark-gray with many minute flakes of mica.

There is a striking variation in the size of the materials. There are many small opaque spherical grains, showing a broken yellow surface by reflected light, sometimes agglomerated into small groups. They are doubtless pyrite or marcasite.

III. Clay

Much short fibrous matter. Black spherules as in the extra fine-grained portion, probably iron sulphide. Flakes of mica.

Summary and Conclusions.—The mechanical composition of this sample calls for little special comment. Its diagram shows the moderate sorting and the abrupt rise of the curve on the left with much slower drop to the right, which has been shown to be characteristic of stream deposits in

small bodies of water. This would be the conclusion even if there were not such startling, almost complete resemblance between the diagram of this sediment (H, p. 169) and that of the delta in the Lagoon of Thau (I, p. 170). The conditions I think may have been exactly those represented now by one of the submerged stream mouths forming the estuaries of Chesapeake Bay, or perhaps by the nearer shore portions of the main body of the bay near the point of discharge of some stream.

The abundance of fossils encountered here for the first time in the sediments analyzed conforms to such an assumption. Their good preservation leaves little doubt that they did live in place and were not transported.

The abundance of fossils encountered here for the first time in the this type as in sample 4.

A peculiar feature is the low percentage of heavy minerals (about 4.5%). But inspection of Thoulet's analyses from the Gulf of Lyon shows that this is so variable a feature that it must be largely dependent on the original composition of the material supplied.

The field relations of this bed require some special mention. The bed lies directly on a white Potomac clay, with a somewhat irregular surface of contact but without any evidence of a coarser basal portion. This seems to confirm the above interpretation. For any swiftly moving water with strong transporting power, or any body of water with strong wave action, must in its progress over a land surface leave a deposit of sorted coarse material, if such is available. Now, such material is available in the Potomac bed under consideration, so that if there had been strongly agitated water this coarse material must have been selected and deposited while the finer material was carried into more quiet water. Then as submergence progressed, finer material would come to overly the coarser with a gradual transition. But if a relatively quiet body of water, deriving its material laterally from some nearby stream emptying into it, transgressed over a surface of such white clay, it would, it seems to me, have only finer material to deposit and therefore put such material down as a bottom layer. Even here, however, slight wave action and therefore slight sorting might be expected, unless the shore were lined with water plants

which broke up the action of the water. The lowest part of the bed might therefore be found slightly coarser on analysis, but no such difference was noted in the field.

It is to be noted that while this bed rests directly on Potomac there must have been a preceding Upper Cretaceous transition over the region (to have furnished the glauconite which in this bed is reworked), followed again by a period of erosion which cut down to the Potomac beds.

Minor features to be especially noted in this sample are:

(1) The well-rounded grains of quartz in the coarser sizes.

(2) The strongly marked solution surface on most of the coarser grains.

(3) The secondary quartz grains.

(4) The grains representing a transition stage between clay and glauconite.

(5) The abundant black mineral granules in the glauconite and in the micas.

SAMPLE NO. 12 (FIG. L, p. 169)

Serial number : 3.
Field number : 11-9-28-1911.
Formation : Monmouth.
Locality : Sassafras River.
Appearance : Loose, coarse, gravelly, dark greenish-brown sand with crumbly lumps of sand in a matrix of grayish-white clay. The loose sand appears to be mainly rounded grains of yellow-stained quartz.

MECHANICAL ANALYSIS

Sample	9.235 gm.
	Per cent of sample
Fine gravel	4.2
Sand	71.1
Clay	25.2
Total	100.5
	Per cent of total sands
Coarse sand	25.2
Medium sand	49.4
Fine sand	16.2
Very fine sand	6.0
Extra fine sand	3.0
Total	99.8
	Per cent of very fine sand
Light	14.0
Heavy: Rejected at 2000 ohms	1.8
Heavy: Attracted at 2000 ohms (glauconite)	74.5
Total	90.3 [1]

[1] It was at first not intended to weigh the products of this separation. Thus they were not weighed till after microscopic study when some had been lost. They are given to show the great dominance of glauconite (the portion attracted at 2000 ohms).

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Fine Gravel

Some of the 22 grains are quite well rounded, others very angular, but even the angular ones show a glossy surface that suggests solution. They are all deeply stained with yellow ocher.

II. Coarse Sand

The glauconite is abundant in this portion, showing its original botryoidal form, but almost all but the smallest grains appear more or less completely ocherized. The quartz grains are like those in the gravel. Of special significance is a grain *half feldspar, half quartz* indicating origin from a nearby granitic rock. The proportion of rounded grains is less than in the gravel.

III. Medium Sand

Differs from the preceding in that more of the glauconite is worn.

IV. Fine Sand

Contains some mica but apparently not yet any heavy minerals.

V. Very Fine Sand

A general dark-green appearance with dark limonitic grains.

VI. Extra Fine Sand

The dark-brown limonitic color predominates in this.

VII. Clay

Yellow, limonitic.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar = 75 : 25.
Though most of the feldspars, like the quartz grains, are stained by ocher, the large proportion of fresh, unweathered feldspars is striking.

(2) Heavy

(a) Attracted at 2000 Ohms

Almost all *glauconite*, so that the identification of other minerals is difficult. The following were recognized: muscovite, epidote, serpentine, staurolite (?). Most of the glauconite is quite opaque, at best only cloudily translucent at the borders.

(b) Rejected at 2000 Ohms

Dominant.—Muscovite, enstatite, zircon.
Rarer.—Rutile, garnet, biotite, tourmaline, serpentine, apatite (?).

II. Extra Fine

Many flakes of brown, granular ocher.

III. Clay

The clay appears all granular, the usual fibrous portions which characterize the clay not having been recognized. This probably means that it is mostly secondary limonitic matter, not primary clay.

Summary and Conclusions.—(1) It is especially to be borne in mind that there is really almost no clay present, the abundant material classified under this head being probably almost all limonite.

(2) The diagram offers little of special interest. It is moderately well sorted sand, intermediate between lagoon and marine conditions, but nearer those of a lagoon. The usual absence in the Monmouth of the black clay peculiar to the Matawan combined with this fairly good sorting suggests more open water conditions, that is, probably a more general submergence. The most striking feature of the sediment is its great coarseness which, with its regular bedding and uniform lateral extension in the field, points to near-shore conditions for its formation. This leads to the third important feature to be noted, namely,

(3) The fact that in such shallow near-shore conditions glauconite is present. This is so contrary to the usual assumption of quiet waters for the formation of glauconite that one is inclined to believe that the glauconite is reworked from adjacent shore bluffs, but in that case evidence of wearing of the glauconite grains would be expected. Still the author does not believe that any modern glauconite-bearing sediment as coarse and as free from clay as this has been found.

Another possibility which suggests itself is that the sediment was formed in deeper water but swept by a strong current. While there are no data for the transporting power of currents in open water it is doubtful that so much of the "coarse" sand could be transported by such means. Moreover, the regularity of bedding in the field is against that assumption.

It is a peculiar sediment and all the more interesting, not only for its peculiarities, but also because in its general appearance in the field it is so typical of the Monmouth formation of the Chesapeake Bay region.

(4) Finally, an important feature is the high percentage of *feldspars* and their appearance of freshness. Their freshness opposes the belief that the material is reworked from an older sediment, while their high proportion, as well as the grain of combined quartz and feldspar noted in the description of the coarse sand, point to origin from nearby.[1]

[1] For the percentage of feldspar in different deposits see Mackie, Wm. The sands and sandstones of E. Moray, Trans. Geol. Soc. Edinburgh, 1896, vol. 7, p. 149.

SAMPLE NO. 13 (FIG. M, p. 169)

Serial number : 1.
Field number : 1-9-14-1911.
Formation : Rancocas (?).
Locality : South of Middletown, Delaware.
Appearance : Coarse loose sand in a weak black clay matrix; weathering shows it to be full of marcasite.

MECHANICAL ANALYSIS

Sample	9.257 gm.
	Per cent of sample
Sands[1]	76.8
Clay	22.0
Total	98.8
	Per cent of total sands
Coarse sand	9.5
Medium sand	60.3
Fine sand	18.1
Very fine sand	6.9
Extra fine sand	5.2
Total	100.0
	Per cent of very fine sand
Light	91.4
Heavy	5.1
Total	96.5

DESCRIPTION OF PRODUCTS

A. UNDER THE HAND LENS

I. Coarse Sand

Grayish-white. Almost all grains are colored by black clay occurring in the irregularities of the surface. The solution effect on these grains is evidently so strong that it almost obscures the original form, producing a glossy but very irregular, deeply-pitted surface. Most of the grains are of clear quartz but a few are granular in appearance and stained dark grayish-black. A very few show dirty greenish staining. In spite of solution effects it is evident that the majority of the grains were originally rounded though there are some that as clearly indicate an original angular form.

II. Medium Sand

Much like the coarse sand but with fewer rounded grains, few of the dark-gray granular grains and with some heavy minerals (garnet, rutile ?, a black, very glossy mineral not magnetite), etc. A little marcasite in the cleavage of some grains but no marcasite nodules were found.

III. Fine Sand

Like the medium sand but with more heavy minerals (rutile especially conspicuous) and the grains still more generally angular.

B. UNDER THE MICROSCOPE

I. Very Fine Sand

(1) Light

Quartz : feldspar=95 : 5.

Feldspar much decayed. Of special interest are the dark-gray grains of quartz, which appear to be full of black flakes like the argillaceous matter which forms the matrix of the bed; these quartz grains polarize as units. When they are crushed the fragments

[1] By summation of parts.

are found still to contain the black flakes which proves that the black material is really on the inside. Grains of the same kind were picked out of the medium-grained sands (the dark-gray grains mentioned in the hand-lens description). Some of these were composed of colorless quartz, others showed a humus-brown color throughout. They also polarized as units and on crushing showed the same dissemination of the black flakes throughout the original grain. I have, therefore, concluded that these grains are secondary, that is, formed after the deposition of the bed.

(2) Heavy

Almost half of this portion appeared to be *magnetite*, and red *garnet* is very common. *Rutile* is also common.

Rarer.—Epidote, tourmaline. pyroxene, chlorite, enstatite, zircon, sillimanite (?). Some of the garnet and epidote are well rounded.

II. Extra Fine

A very dark, brownish-gray, fine-grained, very slightly micaceous powder. This material is finer than in most of the samples because it contains much that usually goes into the silt. Under the microscope it shows much argillaceous matter in brown floccules.

Many small, irregular roundish to perfectly spherical nodules of marcasite. Some of the black nodules of marcasite are fringed by a brown, translucent, isotropic substance. In other cases they are made up of an agglomeration of tiny spherules in a matrix of such substance. There are some chloritic. perhaps a few glauconitic fragments; in addition of course many quartz and feldspar grains.

III. Clay

Dirty brownish-gray. It contains much of the dirty, fibrous, polarizing material besides the usual amorphous brown flocculent matter, and some mineral grains.

Summary and Conclusions.—This is a very peculiar and distinct sediment and must be the product of special conditions which are only partly brought out by the above study, so that no attempt will be made to do more than indicate some of the factors in its origin. The peculiar impression it makes is probably due mainly to its coarseness, its truly black color, its very friable condition, due perhaps to the fact that the black "clay" binder (it is not abundant enough to form a matrix) is not true clay, *i. e.,* not colloidal, or else that the peculiar conditions under which it was deposited destroyed its coherence. The abundance of sulphide (presumably marcasite) and coarse brackish-water features of the fauna sustain the impression of something unusual. One would say a very stagnant lagoon, estuary or delta, yet the diagram (M, p. 169) does not bear this out, for it suggests good sorting, quite as good, excepting for the clay, as in the open-water marly Monmouth (sample 11, K, p. 169). But in considering the sizes involved it is noticed that there is in all the diagrams presented not another one (even marine beach sand) which has the maximum in a portion so coarse as the medium sand ($1\frac{1}{2}$ mm.) It might be

that a swift stream could deposit in its delta a sediment with so much coarse material, but the type of diagram is too far from that of a delta to make such a belief tenable.

Before attempting to adjust these facts some of the peculiarities observed under the microscope should be considered. Foremost among these are the grains of what are called secondary quartz. Humus waters are known to have a strong solvent action on silicates and on silica. The brown, humus coloring of some of the grains of secondary quartz and the envelopes of the same color surrounding some of the marcasite spherules suggest the presence of such matter; yet no carbonaceous matter was found in the bed. Moreover, while decaying animal matter might have precipitated the marcasite, the apparently disseminated occurrence of these spherules and the fact that in the field they were not seen to be concentrated about the fossils seem to demand some other agent. The assumption of algæ would meet these conditions and be in harmony with the general stagnant-water character of the bed. If, however, the precipitation of iron disulphide is attributed to the animal matter the secondary quartz might be accounted for by the former existence of a swamp overlying these beds from which descending humus waters could have produced the secondary quartz, but the knowledge of these processes is still too imperfect to permit of a very trustworthy explanation.

While the assumption of origin in place of the quartz grains described seems to be demanded by their internal structure it should be noted that this interpretation meets with a serious difficulty, that is, the outer form of the grains. This form is that of the normal quartz grains in the deposit, in part rather rounded, in part angular. If they formed in the midst of the bed it does not seem as though they could have found the space to grow freely; they should rather have involved adjacent grains, and the ends of the other grains so involved should give the secondary grain a rough agglomerated appearance. On the other hand, if they formed in some organic mold there should be more regularity and uniformity to their shape. Field sections throw little light on the problems as there are only a couple of feet exposed both vertically and laterally; the only character noted is the presence of fine horizontal clay films on

which fossils are particularly abundant, indicating fluctuations in the conditions of deposition.

In summing up it becomes necessary to neglect the diagram entirely and to rely on the general physical characters. Here the evidence of much humus, the high sulphide content, and the peculiarities of the fauna are indications of a very stagnant, brackish body of water, perhaps surrounded by swamps or filled with disseminated algal growths. The region was evidently near enough to some stream to be affected by fluctuations in its transporting power resulting in the separation of sand layers by clay films and layers of fossils. But the best explanation for the peculiarities of the diagram of this sediment is in just these secondary grains. It is their development that can account for the coarseness of the sand, and one may even assume that they had reached a certain average size, between 1 mm. and ½ mm., to account for the maximum in that size. This interpretation is very hypothetical, but it is the best combination that presents itself for the various partly conflicting factors that are involved. The questions presented require more detailed and extensive study.

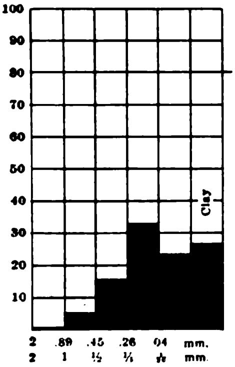
GENERAL SUMMARY AND CONCLUSIONS

The special features of each sediment having been discussed, it remains to sum up the conclusions arrived at and to give a general review of the glauconite in the different samples.

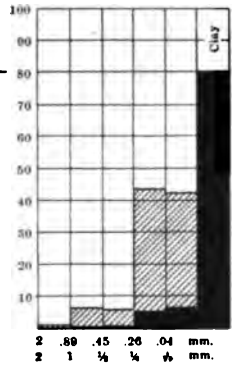
CLASSIFICATION OF THE SEDIMENTS

In the discussion of the 13 sediments studied in this paper three types have been differentiated: (1) The delta type; (2) the estuarine or lagoonal type; (3) the open-water glauconitic type. The character of each may be briefly summarized as follows:

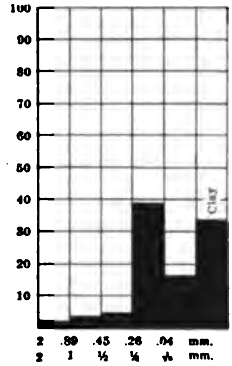
The delta type has as its foremost characteristic the large proportion of a wide range of sizes of sand which a single sample taken from it contains. In the diagram this is expressed by a broad curve with no pronounced maximum. This character is not very markedly affected by the



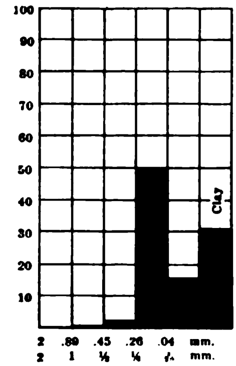
A.—Sample 1. Magothy formation, Betterton.



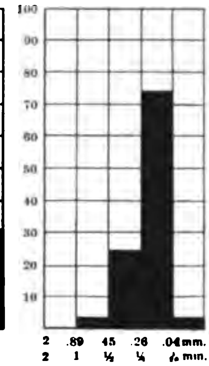
B.—Sample 2. Magothy formation, Betterton.



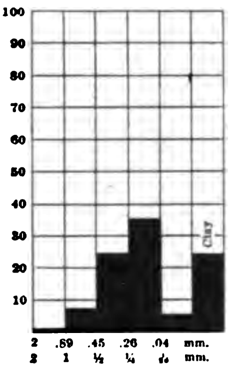
C.—Sample 3. Matawan formation, C. & D. Canal.



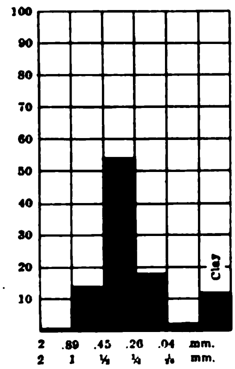
D.—Sample 4. [Same as 3.]



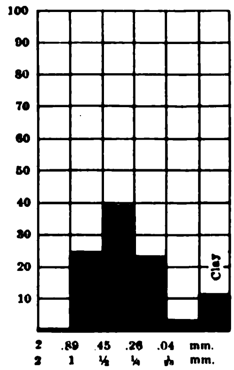
E.—Sample 5. [Same as 3.]



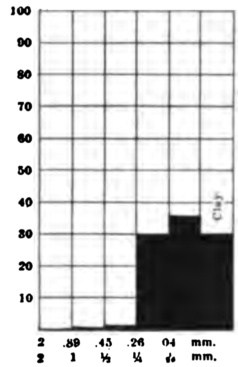
F.—Sample 6. [Same as 3.]



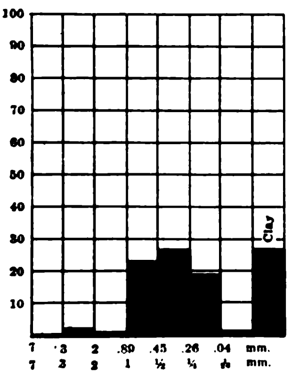
G.—Sample 7. Matawan formation (calcareous), Camp Fox, C. & D. Canal.



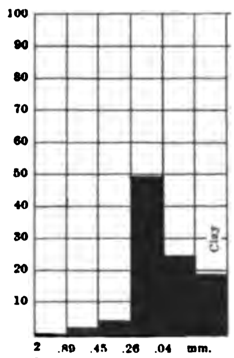
H.—Sample 8. [Same as 7 (non-calcareous).]



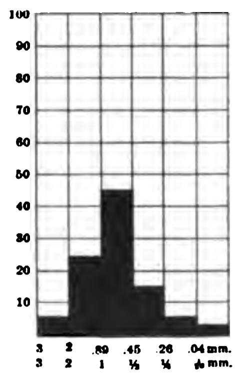
I.—Sample 9. Matawan formation, Grove Point.



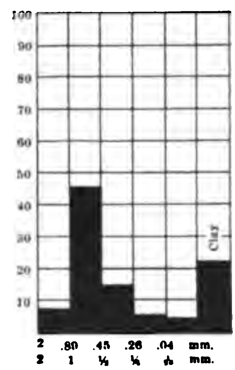
J.—Sample 10. Top of Matawan or base of Monmouth, Sassafras River.



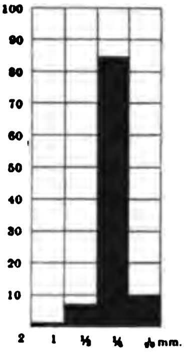
K.—Sample 11. Monmouth formation, Seat Pleasant.



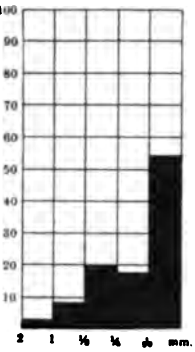
L.—Sample 12. Monmouth formation, Sassafras River.



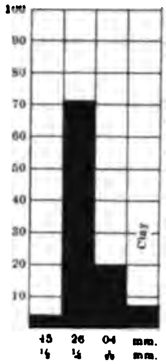
M.—Sample 13. Rancocas formation, near Middletown, Del.



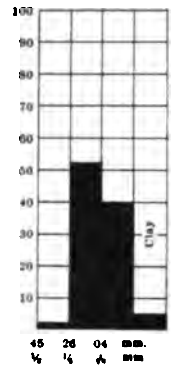
A.—Fresh beach sand. East Indies. Mohr, No. 218.



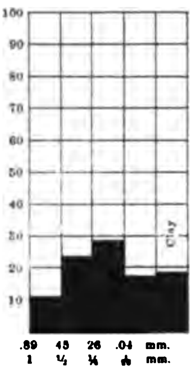
B.—Deeply weathered beach sand. East Indies. Mohr, No. 250.



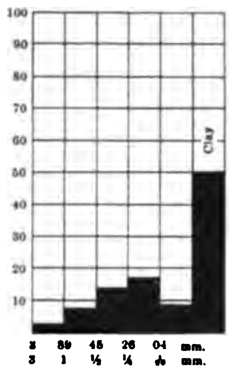
C.—Typical off-shore sediment, Gulf of Lyon. Thoulet.



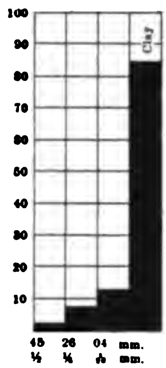
D.—Off Rhone Delta. Thoulet, B40.



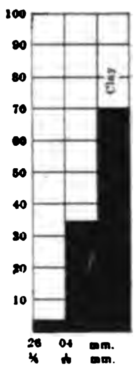
E.—Lagoon of Thau. Sudry, No. 123.



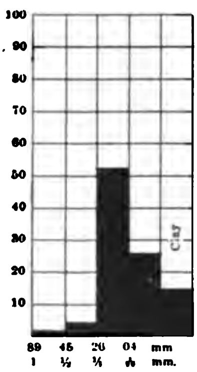
F.—Same as E but finer. Sudry, No. 25.



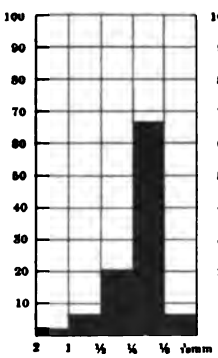
G.—Fine lagoonal sediment. Sudry, No. 49.



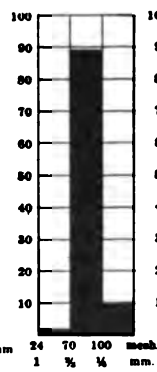
H.—Same belt as G, but in reeds. Sudry, No. 2.



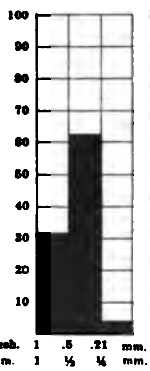
I.—Delta in lagoon. Sudry, No. 110.



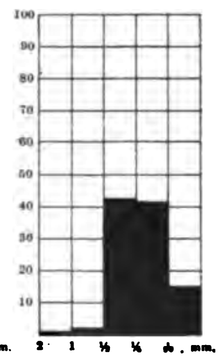
J.—Dune sand (average). Udden.



K.—Dune at mouth of Indus. Oldham.



L.—Sahara sand. Thoulet.



M.—Stream alluvium. Mohr, No. 696.

ratio of sand and clay in the sample, a bed high in clay and low in sand containing almost as large a proportion of coarse material in the sand as does a distinctly sandy bed. With this wide range in the size of the sands there probably also goes, generally, a high ratio of heavy to light minerals, and to a certain extent an abundance of magnetite (*cf.* samples 1-3).

This statement concerning the magnetite is made somewhat doubtfully because there is definite evidence for it only in sample 1; it may be true also of sample 2), but there the mica is so dominant as to leave the percentage of minerals, more certainly classed as heavy by their settling properties, relatively small, and it may also have caused the magnetite to be overlooked. Abundance of magnetite is, moreover, characteristic of sample 11, which must be regarded as a rather typical example of the estuarine type. In the differentiation, at least of two such closely related types, therefore, the proportion of magnetite must not be given much weight. A high percentage of heavy minerals in general seems more likely, however, to be a characteristic of the delta type.

A great abundance of carbonaceous matter is another characteristic of this type, for which, however, the evidence given in these analyses is only qualitative. With this goes the formation of pyrite, or more probably marcasite, which, as will be shown later in the discussion of glauconite, is an alternative product to glauconite, formed in the presence of abundant organic, especially humus matter. It should be noted, however, that as abundant humus matter is also characteristic of many estuarine deposits, so marcasite is found also in these (samples 11 and 13). Furthermore, since the recognition of an opaque mineral of this kind under the microscope is difficult, it is probable that it has been overlooked in some samples in which it might be found if it were especially sought.

Finally, the form of occurrence in the field is very important for the differentiation of this type, which is characterized by thin-bedding, by extreme difference in the proportion of sand and clay in adjacent beds, and by the occurrence of thin sand partings representing, doubtless, temporary stream floods. Moreover, in the argillaceous beds the abundance of mica is usually a conspicuous feature in the field, little streams of carbon-

aceous matter occur, and the high percentage of magnetite is sometimes noticeable.

Under the glauconitic-sand type only the three samples, 7 and 8 from the Matawan, and 12 from the Monmouth, will be considered. Foremost among the characters of the glauconitic sands is their coarseness and the accompanying low percentage of clay. The figures for the clay unfortunately do not bring this out as clearly as they should, on account of the great amount of ocherous matter present, which tends to be separated with the clay. With these striking characters goes better sorting of the sands, that is, a more sharply defined maximum in the diagram, and generally a lower proportion of heavy minerals (the glauconite having been deducted in these samples on the assumption that it was formed in place).

What is called the estuarine type lies between these two other types, and therefore, naturally, shows transitions to both of them. Thus, sample 5, the sandy yellow glauconite bed in the Matawan, would, but for its associations, be classed unhesitatingly with the group of glauconite sands. Indeed, an estuary or lagoon from its very nature can readily become an open body of water, and there is no reason why this may not be assumed to have happened here. There is the characteristic sorting of the sands, the only difference from the other glauconitic sands being the greater fineness of the maximum size; but there is no reason for believing that such a character cannot belong to a typical glauconite sand; and the limited number of analyses of typical glauconite sands does not justify making a contrary generalization.

The most conspicuous feature of what is called the estuarine or lagoonal type is of course the characteristic black, argillaceous appearance of the Matawan, by which it is so readily recognized in the field. The cause of this coloring is one of the unsolved problems in the study of these deposits. In the normal samples of this type the clay itself, when separated, is of the ordinary blue-gray color. The black color cannot be attributed to organic matter since that is, in the most characteristic samples, not unusually abundant, and moreover, it may be seen from the Magothy that the pres-

ence of carbonaceous matter does not tend to give that color but rather the blue-gray. Perhaps the color is in some way the result of the characteristic on which these beds have been differentiated, the mixture of an abundance of fine-grained sand with a moderate amount of clay, which results from the wide range in the size of the material forming the bed. That is to say, these beds being predominantly fine-grained should consist mainly of extra-fine sands with much clay. But as a matter of fact, while most of them are very high in extra-fine sands and contain much clay, they contain, in many cases, even more very fine sands, and usually also a considerable proportion of some of the coarser sizes. The most marked exception to this general wide range in sizes is sample 5, which, as just stated, is really a glauconitic open-water deposit. Sample 6, which is closely associated with sample 5, shows much less divergence from such composition; while all the others satisfy reasonably well the description just given. Sample 9 diverges from the normal estuarine type again in the other direction, that is, towards the delta type; but its affinities with this type were already pointed out in the summary and discussion of it. To a somewhat less extent the same is true of sample 11, as was also explained in the summary and discussion there. These divergences all serve merely to bring out the intermediate character of the estuarine type.

In conclusion, if the distribution of the three types of sediments as defined in the different formations is considered it is found that the samples studied from the Magothy are distinctly of the delta type. In the Matawan and in the Monmouth both the estuarine and the open-water glauconitic types are found. This is not surprising. Even without the evidence afforded by sample 10 for the Monmouth we know and might expect that in both periods there was transgression, and this transgression might well be estuarine in its basal portion. Thanks to the good section afforded by the Chesapeake and Delaware Canal, the relation of samples 4 to 8 is clear, and it is in conformity with this relation that the higher portion represented by samples 7 and 8 should be of a deeper-water type than the lower portion (samples 3 to 6). The stratigraphic relation of

the two Monmouth samples 11 and 12 is not so clear, but it is perfectly reasonable that sample 11 should be of the estuarine and sample 12 more of the deeper-water type whether they are the product of different more or less contemporaenous facies, or of successive stages in a transgression.

There is a general feature which was not taken up in the discussion of the individual samples because the facts were not sufficiently significant. This is the mineral content of the beds. It was thought that some light might be thrown on the source of the material by the rarer minerals: but their most striking characteristics are their similarity in different beds and their apparently nearby origin. Moreover, their resemblances are not only with each other but extend far beyond to such sedimentary beds in general as have been studied from this point of view. Many of the same minerals will be found to prevail, for instance, in the materials studied by Cayeux and Thoulet,[1] or in other such studies as listed by Andrée.[2] Even common experience teaches the prevalence of magnetite in stream-borne sands; and epidote while less easily recognized is probably almost as common, is in fact said by Van Hise[3] to be one of the characteristic minerals of sedimentary rocks. Equally, or even more frequent are chlorite and muscovite. Tourmaline, rutile, and zircon survive in almost all sediments if there is any source for them. The persistance of enstatite in these samples is apparently a more local character but can be accounted for by the occurrence of the mineral in the rocks of the neighboring Piedmont region. It tends to bring out, however, the predominance of minerals that might at least be of nearby origin, in these sediments. It is this fact which obscures other evidence and makes it possible to say only that the Piedmont region appears to be the source of most of this material. But in this connection two important facts should be noted. One is that the Piedmont region is petrographically so

[1] Cayeux, Lucien, Contribution à l'étude micrographique des terrains sédimentaires. Mém. de la Soc. Géol. du Nord., T. iv-2.——Thoulet, J., Etude bathylithologique des côtes du Golfe du Lion. Annales. de l'Inst. Océanograph. T. iv, Fasc. 6, Paris, 1912.

[2] Andrée, K., Sedimentbildung am Meeresboden. Geol. Rundschau. vol. 3, 1912, pp. 324-338.

[3] Van Hise, C. R., A treatise on metamorphism. Mon. U. S. Geol. Survey, No. 47, 1904.

varied that it could furnish almost any of the more usual rock-forming minerals; the other is a fact that is, perhaps on account of its unwelcome character, all too generally ignored in work of this kind, namely that the older sedimentary rocks—limestones, shales, or sandstones—contain heavy minerals just as do the rocks being studied, and that a region of sedimentary rocks is not going to yield, at least at a distance, fragments of limestone and shale, but rather the mineral grains that were included in the limestone and shale. Thus the problem is seen to be a very complicated one, in which only the most general results are readily obtained. If this side of the work is to be developed it will probably be necessary either to find unusual minerals and trace them, or else to differentiate by a close mineralogic study varieties of common minerals, such as feldspars, augites, hornblendes, or even quartz, as Mackie has done,[1] and then trace down to its source the particular variety thus identified. This requires, however, close study not only of the sediments but also of the rocks from which their minerals may have been derived, and this becomes a long and arduous problem. Without such work the study of mineral grains in sedimentary rocks does not, in most cases, yield much of value.

It will have been noted that in all the sediments studied the coarser sizes of sand had a glossy pitted surface which seemed plainly to indicate solution of the grains after deposition. This phenomenon appeared so general that it cannot be connected with the particular composition of the bed. Evidently the ordinary circulating ground water is the agent. The chemistry of the process is not understood, though humus waters are supposed to be particularly effective. According to the more recent theories, which deny the existence of humus acids, this is probably due to the carbonic acid.

More limited in its observed occurrence in these samples is the deposition within the sediment of quartz from solution. The evidence for this appeared most convincing in sample 13, but associated with deposition of silica there is here to an unusually pronounced degree the same solution of silica as noted on the quartz grains in most of the other

[1] Mackie, Wm., The sands and sandstones of E. Moray. Trans. Geol. Soc. Edinb. vol. 7, 1896, pp. 148-172.

samples. While the coexistence of solution and deposition of the same substance in a bed seems at first inconsistent it may nevertheless be in conformity with the recognized principle of chemistry that among particles of substance in a medium in which they are partly soluble the larger particles will tend to grow at the expense of the smaller. Or the nuclei around which deposition took place may have been in some way chemically different. Whether these supposed secondary grains have definite nuclei and what these nuclei are was not determined, though thin sections might throw some light on the question. The peculiar completeness in the form of these grains was noted and seems to be the fact most inconsistent with the hypothesis of their secondary origin. That strong chemical action is indicated by the abundant deposition of sulphide in the bed should be borne in mind in this connection.

To conclude the general summary it may be said that in all the samples, no matter what the form of the coarser sizes of sand, there is never any appreciable amount of rounding below the fine-sand size (*i. e.*, ½ mm. to ¼ mm.).

THE GLAUCONITE

Collet's[1] little manual on marine sediments contains so complete and up-to-date a summary by a specialist on glauconite, contributing even some hitherto unpublished data, that it is unnecessary to enter into a general discussion.

But perhaps by way of preface, since others may, like the writer, have considered glauconite a comparatively rare mineral, it will be worth while to draw attention to its distribution in marine sediments. So common is it, indeed, that Collet considers it necessary to explain its absence rather than its presence.[2] It is found more or less along the coast of all the oceans at depths varying from 91 m. along the northern Atlantic coast of the United States to 3512 m. in the Indian Ocean. In the red clays which cover the greater depths, it is, for some undetermined reason, absent.

[1] Collet, L. W., Les dépots marins, pp. 132-194, 303-306. Paris: Octave Doin, 1908.

[2] Collet, pp. 303-306, addenda on the red clays.

Of the three forms of glauconite differentiated by Collet, all three are found in these sediments. The grains which in this paper have been described as botryoidal are those called *casts* by Collet, that is, they are believed to owe their form to their origin within the shells of Foraminifera. A very few grains were noted that had the form of other small shells, but the shells were not further determined. The description of the products shows that this form of glauconite occurs mainly in the medium and fine sands, occurrences in the coarse sand having usually the appearance rather of secondary agglomerations of smaller grains, while only few if any such grains without signs of wear are found in the very fine sands. This distribution means a range of size pretty well within the limits of 0.3 mm. to 0.9 mm. diameter. Collet[1] gives an upper limit of 1 mm.

The second kind of grain defined by Collet is simply a grain showing no trace of an original mould. To this category belong the rounded grains which prevail in the very fine and finer portions of sediments with primary glauconite, and which as *reworked glauconite* enter into other beds. It is generally agreed that they are derived through the rounding by attrition of the glauconite casts.

To Collet's third type, the fragmentary glauconite, belongs what is here called glauconite stain; that is, the glauconite adhering like clay to the outside or filling the fissures of mineral grains.

Concerning the origin of glauconite, Collet's own conclusion that the processes are still very little understood may be emphatically cited. But the facts of observation at least give much evidence as to the conditions under which it takes place.

It is generally believed that a certain amount of organic matter is essential to the process, but an excess of it seems, on the other hand, to interfere. Collet[2] gives the formula, which appears to be generally accepted, by which decomposition of organic matter precipitates FeS (p. 171). As he explains, this FeS is believed to be capable of giving up its iron directly to silicates to form iron silicates, but an excess of organic matter interferes with the process and thus leads to the accumulation

[1] Collet, L. W., Op. cit., p. 133.
[2] Collet, L. W., Op. cit., pp. 169, 170.

of pyrite as noted above in this summary. Whether this is due to the presence of an excess of H_2S as he mentions on page 171, or to the humus compounds (the existence of humic *acids* is now generally discredited) as in lake deposits[1] has not been proved; recent observations tend to show that certain special bacteria are factors both in the precipitation of FeS and in its oxidation to FeS_2; but whatever the process the fact may be accepted that in the presence of abundant organic matter in fairly quiet waters FeS_2 is formed. Collet presents for the steps of the process of glauconite formation an explanation,[2] somewhat simplified from that of Murray and Renard, based on elaborate and extended studies of his own. In both theories, to start with, a colloid is assumed. Murray and Renard conceive of the production of colloidal silica by the action of sulphuric acid derived from the oxidation of the FeS present, while Collet starts merely with the colloidal matter of clay. This, through the processes of sedimentation, has naturally come to fill the forminiferal shells present. The Al of the clay is first exchanged with Fe, and this new compound combines with potassium present in the sea water, and also with some water, to form the glauconite. In support of this theory Collet finds many intermediate stages from grains having the appearance of fresh clay to grains turned increasingly deep brown by taking up iron. The writer's observation of grains having the form of glauconite, the appearance of clay, but an aggregate polarization, was made without any knowledge of Collet's observations and is therefore independent testimony in support of this view.

The occurrence of similar material in sample 11 (p. 160, above), which contains FeS_2 (marcasite ?), is perhaps more questionable. Moreover, on reviewing the sediments as a whole, the writer is not inclined to consider the little clay accretions or nodules in the sulphide-bearing samples 1 and 2 as related to the glauconite. On the contrary, in view of the impregnation of organic fragments with some iron salt (probably marcasite) that is shown to have taken place there, it seems more probable that this same mineral is responsible for the clay nodules. In fact, these questions can be

[1] Collet, L. W., Op. cit., pp. 178, 179.
[2] Collet, L. W., Op. cit., p. 176.

solved only by getting different stages in the processes involved, and perhaps by chemical analysis, and the present observations are not considered as sufficiently extended to give ground for interpretation of the facts observed.

In view of the very undeveloped state of knowledge of the actions of colloids, the uncertainty about the processes involved in the formation of glauconite is very comprehensible. The known power of colloids to absorb without chemical combination variable amounts of different substances may also account for the indefinite composition indicated by analysis. Against this apparent variability Collet's protest[1] that most of the samples analyzed were not made up of perfect glauconite seems invalid since his only criterion was fresh green color and, and there is no evidence that within material of this green color there are not imperceptible variations in degree of what he himself (p. 176) calls "glauconitization." Indeed, the wide difference in tone between samples of glauconite from different localities would seem to indicate that there is such a variation. The only analysis that could by itself definitely be set up as establishing the composition of glauconite would be of good crystals of the substance, but recognizable crystals identified as glauconite are so rare and so small when they do occur that chemical analysis has not been possible.[2] Moreover, it may well be that glauconitization does not tend at all toward the formation of a single definite compound and that different glauconites are only different members of a series like the chlorites to which they are by some supposed to belong, or like other micas. That this is probable is indicated by Collet's discussion[3] of the crystal identified by Cayeux, which he shows has different optical properties from others that have been described.

However, there is strong evidence in favor of Collet's view of the process. First of all, it seems certain that it must start from clay, since the foraminiferal shells are sure to be filled with that substance by the progress of sedimentation. Murray's assumption of sulphuric acid to

[1] Collet, L. W., Op. cit., p. 167.
[2] See discussion of determined crystals in Collet.
[3] Collet, L. W., Op. cit., p. 136.

decompose this clay, as the initiation of the process, appears paradoxical since the acid would first of all dissolve the shells forming the mould and thus allow the as yet unaltered clay at once to disintegrate.

These processes, moreover, seem to account for much of the glauconite stain, that is, the glauconite forming patches and fissure fillings on and in the grains of quartz and feldspar associated with glauconite. It is, of course, possible that glauconite is formed as a fine powder from the loose clay outside of any enclosing body, and it may well be this glauconite that forms adhering patches on the outside of some grains. But any fissure into which this could penetrate would surely be filled long before by fine argillaceous material, so that here again it seems that the glauconite in the fissures of quartz and feldspar must be formed by the alteration of an argillaceous product. The unusual thickness of some of these seams in grains of feldspar, moreover, suggests that they are more probably derived from the alteration of kaolin formed in the fissure by the alteration of the feldspar than from clay introduced from outside, since it is very improbable that an open cleavage crack of that width would exist in a grain of feldspar.

Concerning the two closely related problems of inclusions in glauconite, and decomposition of the glauconite, the present observations afford only confirmation of recognized facts. Thus the decomposition of glauconite to yield limonite is generally accepted and is conspicuously evident in the open-textured Monmouth sands. The clouded appearance of the grains of these samples under the microscope is doubtless the result of this process. The occurrence of clear, fresh-looking grains in the samples of Matawan from the Chesapeake and Delaware Canal (samples 3 and 4) is on the other hand probably due to the protective action of the clay in which they occur.

Glauconite with inclusions of black grains (pyrite or magnetite[1]) were observed only in samples 8 and 11. In sample 8 it is noteworthy that the micas, too, are full of black grains. Now, magnetite

[1] The differentiation of pyrite and magnetite from each other when they are thus included in glauconite is, of course, difficult or impossible without chemical means.

is a decomposition product of biotite, and biotite may also be bleached or converted into chlorite, so that the micas present in this sample might all be derived from the decomposition of biotite. On the other hand, this bed is also sulphide-bearing. Cayeux has suggested that pyrite and magnetite might be introduced into glauconite grains subsequent to their formation, but not, presumably, in a loose sediment of this kind. Collet notes (p. 160) that those inclusions in glauconite are more common in ancient than in modern sediments. Might not these black grains, then, be magnetite produced by decomposition of the glauconite as it is produced in biotite?

There is one fact specially noteworthy about the glauconite sands of the Monmouth, that is, the coarseness of the accompanying sand. The associations in the Matawan are normal since Thoulet found it even in the narrow coastal strip of the Gulf of Lyon which he studied,[1] but its occurrence in sediments as coarse as these (in fact as the whole Monmouth and Eocene of this region) is not recognized in modern sediments. On the other hand, there is no theoretic reason against such an association.

According to Collet the feldspars associated with glauconite are predominantly basic, of about the composition of labradorite. While no specific identification of the feldspars present was made the writer's observations do not at all confirm this conclusion. The twinning characteristic of plagioclase feldspars was exceedingly rare, and the index of refraction of the feldspars was, moreover, almost invariably lower than that of the liquid (1.548) in which they were immersed, which would imply nothing more basic than oligoclase. These observations do agree, however, in that orthoclase seemed to be scarce.

The degree of weathering of the feldspars in the glauconitic samples is very variable, and is in these ancient sediments doubtless determined largely by secondary effects after their exposure. This belief is confirmed by the fact that feldspars are scarcest in those samples (9 and 11) which show clearly their derivation from the erosion of a deposit previously formed, which in the interval before it was reworked must

[1] Thoulet, J., Etude bathylithologique des côtes du Golfe du Lion. Annales de l'Inst. Océanograph. T. iv, Fasc. 6, Paris, 1912, p. 62, *et seq.*

have been exposed to atmospheric weathering, and at that time probably lost a part of its feldspars by decomposition. Generally the feldspars are about 10% of the light portion. The high percentage (25%) in sample 10 is probably due to derivation of the material from nearby.

The observations on mica also agree in a general way with Collet's conclusions in that mica is not abundant in the samples with primary glauconite, while in very micaceous samples primary glauconite does not occur. But this may be due mainly to the fact that the glauconitic sands are usually coarser and in such coarse sediments mica is generally more scarce. More advanced decomposition of the mica in glauconitic samples was not noticed.

THE UPPER CRETACEOUS FLORAS OF THE WORLD[1]

BY

EDWARD WILBER BERRY

Introductory

The Upper Cretaceous was a period of world-wide transgressions of the sea, in consequence of which its deposits are abundantly represented on all of the continents by marine fossiliferous deposits. Invertebrate paleontologists, especially those of France, have taken the lead in determining its subdivisions, the most prominent stratigraphic elements in its faunas being aberrant Rudistæ, both the Dibranchiate and Tetrabranchiate Cephalopoda, and *Micraster* and other genera of Echinoidea.

Fossil plants occupy a relatively unimportant place in the correlation of the predominantly marine formations of the period. They are, nevertheless, much more abundant than in the Lower Cretaceous. In the initial deposits of the Upper Cretaceous sea (of different age in different areas) they become most important factors in correlation, as in the case of the Dakota sandstone of the West, the initial deposits of the Atlantic Coastal Plain, or those of Bohemia, Saxony and the Prussian Border.

Both the lower and upper limits of the Upper Cretaceous have occasioned prolonged discussion. Long-established usage in England and the ruling of the International Geologic Congress make the Albian the lowest stage of the Upper Cretaceous, and this usage is in harmony with the fact that the first widespread Upper Cretaceous transgression of the sea was inaugurated in the Albian. Haug (*Traité,* 1910) considers the Albian, Cenomanian and Turonian as a separate major division which he terms Mesocretaceous, and his usage has many commendable features.

[1] **All references to Diatoms are omitted, as are also most scattered references to marine algæ.**

Continental geologists usually consider the Albian as the uppermost stage of the Lower Cretaceous and this was the usage followed by the writer in the Maryland Geological Survey volume on the Lower Cretaceous. The upper limit of the Cretaceous is involved in the so-called Laramie problem of American geology and in the discussions of the age of the *étage Montian* of the European section. Since all of the Maryland floras and faunas are considerably older, the question of the Cretaceous-Eocene boundary does not concern the present discussion.

The Upper Cretaceous sediments of Europe were early differentiated into the following four lithologic units: (1) *Craie glauconieuse* or *grès vert supérieur,* (2) *craie marneuse,* (3) *craie blanche,* (4) *calcaire pisolithique*. These four divisions were named:

Cenomanian, d'Orbigny, 1843 (from Mans, Sarthe).
Turonian, d'Orbigny, 1843 (from Touraine).
Senonian, d'Orbigny, 1843 (from Sens, Yonne).
Danian, Desor, 1850 (from the extensive development of the *calcaire pisolithique* in Denmark), equivalent of Garumnian, de Leymerie, 1862 (from Garonne).

These terms of d'Orbigny are still widely used, the only material modification being the recognition of the greater importance of the Senonian, which is now divided into two stages of equal rank with Cenomanian and Turonian. For the following paleobotanical discussion the writer has adopted the readily understood terminology of the fifth edition of de Lapparent (1906), which is as follows:[1]

DANIAN

ATURIAN[2]	MAESTRICHTIAN (from Maestrict = DORDONIAN, Coquand, 1858). CAMPANIAN (from the Champagne, Coquand, 1858).	UPPER SENONIAN.
EMSCHERIAN[3]	SANTONIAN (from Saintonge, Charente, Coquand, 1858). CONIACIAN (from de Cognac, Charente, Coquand, 1858).	LOWER SENONIAN.

[1] de Lapparent includes the Montian in the Cretaceous, but the best modern usage as advocated by Dollo, Lemoine and Haug places it in the basal Eocene.

[2] Munier-Chalmas and de Lapparent, 1893, from Aturia (Adour).

[3] Emscher, Schlüter, 1874; Emscherian, Munier-Chalmas and de Lapparent, 1893, from Emscher, Westphalia.

TURONIAN { ANGOUMIAN (from Angoulême, Coquand, 1858) (= PROVENCIAN)
LIGERIAN (from the Loire basin, Coquand, 1858) (= SAUMURIAN, Grossouvre).

CENOMANIAN { Sometimes divided into an upper Caretonian and a lower Rhotomagian substage (Coquand, 1858).

The European Upper Cretaceous is divided into two provinces—the Northern and the Mediterranean, and in recent years the minor faunal facies have been worked out in the greatest detail, especially in France.

In the discussion of Lower Cretaceous floras (*op. cit.*) it was found feasible to discuss them by stages. There are, however, so many debatable florules in the Upper Cretaceous and the literature is so much more voluminous that a similar treatment would be more confusing than serviceable. For example, the celebrated Aachen sands are considered Santonian by some continental authorities, while others regard them as basal Campanian. The same question arises in connection with the equally celebrated plant beds of the so-called subhercynian Cretaceous and other illustrations might be given to show that a chronologic treatment, such as sufficed for the Lower Cretaceous, would prove much less serviceable than a discussion by regions which facilitates the introduction of more stratigraphic notes, keeps the literature well grouped in the order of its development, and in no wise diminishes the value of the lists for purposes of correlation. Certain references to geologic literature and comments on local stratigraphic relations of foreign areas are introduced for the benefit of American students. Similarly, discussion of the very extensive Upper Cretaceous floras of the United States is very much reduced, since it would enlarge this chapter out of all proportion to its value, and furthermore this data can readily be obtained by anyone having access to the official geologic publications of this country.

NORTH AMERICA

GREENLAND

Few regions within the Arctic Circle have been studied by geologists and paleontologists as thoroughly as the region including Disko Island and the Nugsuak Peninsula. Beginning with Inglefield's third Arctic

voyage in 1854, the region has been visited by Olrik (1859), Torrell. Rink (1848-1851), Whymper (1867), Nordenskiöld (1870), Freist and Nauckhoff (1871), Steenstrup, Pfaff, Jorgensen, Krarup Smith, Peary (1897), Drygalski, and other explorers and naturalists. The geology has been described by Brown,[1] Nordenskiöld,[2] K. J. V. Steenstrup,[3] White and Schuchert,[4] and a detailed map by Hammer and Steenstrup[5] is available. Heim[6] spent some time in this region in 1909, and has made several contributions remarkable for the fine photographs with which they are illustrated.

The elaboration of all of the early collections was entrusted to Professor Heer and forms such a considerable portion of the seven splendid volumes of his "Flora Fossilis Arctica" (1868-1883). The history of exploration has been given by Brown and Nordenskiöld, and rather extensive accounts of the paleontological studies of Heer upon this material have been published by Saporta,[7] Ward,[8] and others.

Paleobotanists have eagerly awaited an expected revision of Heer's work by Nathorst, since the bulk of the materials upon which that work was based are in the Natural History Museum at Stockholm, but only two

[1] Brown, R., Geological notes on the Noursoak Peninsula, Disco Island, and the country in the vicinity of Disco Bay, North Greenland. Trans. Geol. Soc., Glasgow, vol. v, 1875, pp. 55-112, with map.

[2] Nordenskiöld, S. E., Account of an expedition to Greenland in the year 1870. Geol. Mag., vol. ix, 1872. pp. 289-306, 355-368, 409-437, 449-463, 516-524, pl. vii (map), viii.

[3] Steenstrup, K. J. V., in Heer, Fl. Foss. Arct., Bd. vii, 1883, pp. 228-250, with map. Meddelelser om Grönland iv, 1893, pp. 173-243, with map. *Ibidem*, v, 1893, pp. 1-78, with map.

[4] White and Schuchert, Cretaceous series of the West Coast of Greenland. Bull. Geol. Soc. Am., vol. ix, 1898, pp. 343, 348, pl. xxiv-xxvi.

[5] Hammer and Steenstrup, Meddelelser om Grönland, Heft iv, 1893.

[6] Heim, A., Ueber die Petrographie und Geologie der Umgebungen von Karsuarsuk, Meddelelser om Grönland, Bd. xlvii, No. 3, 1911, pp. 175-228, pl. ix (map), 2x. Heim, A. and Rikli, M., Sommerfahrten in Grönland, Frauenfeld, 1910.

[7] Saporta, G. de, Ann. Sci. Nat., 5e série, Bot. t. ix, pp. 86-126, 1868. Congr. Intern. Sci. Géog., Paris, 1875, Compte rendu, t. i, pp. 197-242, pl. iv, v, 1878.

[8] Ward, L. F., 8th Ann. Rept. U. S. Geol. Surv. for 1886-88, pp. 830-834, 1889.

short papers by the latter author have thus far been published.[1] A few of the species collected by White and Schuchert have been identified by Knowlton (*op. cit.*); and Beust,[2] Vanhöffen and Englehardt,[3] and Menzel[4] have published short papers relating to this area.

The Upper Cretaceous beds form part of a sedimentary series with a thickness of about 4000 feet, derived from the eastward and embracing Lower (Kome), Middle (Atane) and Upper (Patoot) Cretaceous, as well as the so-called Arctic Miocene, which according to Menzel (*op. cit.*) is partly Aquitanian. The clastic beds are exposed at numerous points along the deeply indented coast in a belt about 75 miles wide, extending from latitude 69° 15′ to 72° 15′ north. They rest on a very irregular floor of gneiss, granite, diorite and basalt and dip slightly to the westward, although they are faulted locally and show variations in thickness. They are overlain by from 3000 feet to 4500 feet of horizontally bedded Tertiary basalt.

Heer considered all of the north shore of the Nugsuak peninsula from Kome westward to Ekorgfat as belonging to the Kome series, although in places the sediments are as much as 1500 feet in thickness. Nordenskiöld considered the beds above 750 feet above tide as representing the Atane beds, since he found fragments of *Sequoia fastigiata,* an Atane species, at this level, although there appears to be no lithologic break.

The work of White and Schuchert (*op. cit.*) as well as that of Vanhöffen and Engelhardt (*op. cit.*) confirm Nordenskiöld's results and show that

[1] Nathorst, A. G., Ueber die Reste eines Brotfruchthaums, *Artocarpus dicksoni* n. sp., aus den cenomanen Kreideablagerungen Grönlands. Kgl. Svenska Vetens.-Akad. Handl., Bd. xxiv, No. 1, 1890, 10 pp. 1 pl.

Idem, Paläobotanische Mitt. 1, *Pseudocycas*, eine neue cycadophyten Gattung aus den cenomanen Kreideablagerungen Grönlands. *Ibidem*, Bd. xlii, 1907, No. 5, pp. 3-11.

[2] Beust, F., Untersuchung über fossile Holzer aus Grönland. Inaugural Dissertation, Zurich, 1884, Neue Denks. Schweiz. Naturw. Gesell., pp. 1-43, pl. i-vi.

[3] Vanhöffen und Engelhardt. Die fossile Flora in Drygalski's Grönland Exped. Gesel. für Erdkunde zu Berlin, Bd. ii, Theil i, 1897, pp. 358-373, figs. 25-30.

[4] Menzel, P., Ueber arktische Fossilflora. iii, Jahrb.-Ber. Frieberger Geol. Gesell. Freiberg, 1910, pp. 46-49.

the flora is not so unique nor necessarily as old as it was considered by Heer. The Kome flora was enumerated by the writer in 1911.

The ripple-marked sandstone at Ekorgfat and the coal deposits indicate continental conditions of deposition for the bulk of the materials, and suggest the Kootenai formation of western North America.

C. Giesecke, who lived in west Greenland from 1806 to 1813, and whose journal has recently been republished (1910) in "Meddelelser om Grönland," was the first to discover the Kome plants as well as those on the east coast of Disko Island.

The Atane Series

The Upper Cretaceous sediments of the Atane and Patoot series attain a thickness of at least 1300 feet. Along the South shore of the Nugsuak peninsula they rest on a brecciated pre-Cretaceous basalt. At Ata, the type locality of the Atane series, they consist of buff sandstones interbedded with more or less laminated and carbonaceous, often "burnt" shales carrying fossil plants and a few marine invertebrates. Following is a list of the fossil plants recorded from the Atane series:

Acer edentatum Heer
Acerates arctica Heer
Alisma ? reticulata Heer
Anacardites amissus Heer
Andromeda parlatorii Heer
Andromeda pfaffiana Heer
Apeibopsis thomseniana Heer
Aralia grönlandica Heer
Aralia ravniana Heer
Artocarpus dicksoni Nathorst
Arundo grönlandica Heer
Aspidium fecundum Heer
Aspidium jenseni Heer
Aspidium schouwii Heer
Asplenium dicksonianum Heer
Asplenium försteri Debey and Ettingshausen
Asplenium nordstromi Heer
Baiera incurvata Heer
Baiera leptopoda Heer
Baiera sagittata Heer
Carpolithus scrobiculatus Heer

Cassia angusta Heer
Cassia antiquorum Heer
Cassia ettingshauseni Heer
Celastrophyllum obtusum Heer
Chondrophyllum orbiculatum Heer
Cinnamomum newberryi Berry
Cissites affinis Lesquereux
Cissites formosus Heer
Cladophlebis socialis (Heer) Berry
Colutea coronilloides Heer
Colutea langeana Heer
Colutea primordialis Heer
Colutea valde-inaequalis Heer
Cornus forchhammeri Heer
Credneria integerrima Zenker
Cunninghamites borealis Heer
Cyathea fertilis Heer
Cyathea hammeri Heer
Cyparissidium gracile Heer
Dalbergia hyperborea Heer
Dalbergia rinkiana Heer
Dammara borealis Heer
Dammara microlepis Heer
Dermatophyllites acutus Heer
Dermatophyllites borealis Heer
Dewalquea groenlandica Heer
Dewalquea insignis Hosius and von der Marck
Dicksonia conferta Heer
Dicksonia groenlandica Heer
Dicksonia (Protopteris) punctata (Sternberg) Heer
Diospyros primæva Heer
Diospyros prodromus Heer
Dryopteris örstedi (Heer) Knowlton
Equisetum amissum Heer
Eucalyptus borealis Heer
Eucalyptus geinitzi Heer
Ficus atavina Heer
Ficus crassipes Heer
Ficus hellandiana Heer
Ficus protogæa Heer
Ginkgo multinervis Heer
Ginkgo primordialis Heer
Gleichenia acutiloba Heer
Gleichenia comptoniifolia (Debey and Ettingshausen) Heer
Gleichenia giesekiana Heer
Gleichenia gracilis Heer
Gleichenia nauckhoffii Heer

Gleichenia obtusata Heer
Gleichenia zippei Heer
Hedera cuneata Heer
Hedera primordialis Saporta
Hysterium protogæum Heer
Ilex antiqua Heer
Juglans arctica Heer
Juniperus hypnoides Heer
Juniperus macilenta Heer
Lamprocarpites nitidus Heer
Laurus atanensis Berry
Laurus hollæ Heer
Laurus odini Heer
Laurus plutonia Heer
Leguminosites amissus Heer
Leguminosites atanensis Heer
Leguminosites delageri Heer
Leguminosites insularis Heer
Leguminosites macilentus Heer
Leguminosites orbiculatus Heer
Leguminosites ovalifolius Heer
Leguminosites prodromus Heer
Liriodendron meekii Heer
Macclintockia appendiculata Heer
Macclintockia cretacea Heer
Magnolia alternans Heer
Magnolia capellinii Heer
Magnolia isbergiana Heer
Magnolia obtusata Heer
Majanthemophyllum cretaceum Heer
Marsilia cretacea Heer
Menispermites borealis Heer
Menispermites dentatus Heer
Metrosideros peregrinus Heer
Moriconia cyclotoxon Debey and Ettingshausen
Myrica emarginata Heer
Myrica fragiliformis (Zenker) Engelhardt
Myrica longa Heer
Myrica thulensis Heer
Myrsine borealis Heer
Myrtophyllum parvulum Heer
Nelumbium arcticum Heer
Nilssonia johnstrupi Heer
Onoclea inquirenda Hollick
Osmunda obergiana Heer
Otozamites ? groenlandica Heer
Paliurus affinis Heer

Panax cretacea Heer
Pecopteris bohemica Corda
Pecopteris borealis Brongniart
Pecopteris pfaffiana Heer
Pecopteris striata Sternberg
Phegopteris jorgenseni Heer
Phyllites granulatus Heer
Phyllites incurvatus Heer
Phyllites lævigatus Heer
Phyllites linguæformis Heer
Phyllites longepetiolatus Heer
Pinus olafiana Heer
Pinus staratschini Heer
Pinus (Abies) upernivikensis Heer
Pinus vaginalis Heer
Pistia nordenskioldi (Heer) Berry
Platanus heerii Lesq.
Podozamites latipennis Heer
Podozamites marginatus Heer
Podozamites minor Heer
Podozamites tenuinervis Heer
Populus amissa Heer
Populus berggreni Heer
Populus hyperborea Heer
Populus stygia Heer
Protophyllocladus subintegrifolius (Lesq.) Berry
Pseudocycas dicksoni (Heer) Nathorst
Pseudocycas insignis Nathorst
Pseudocycas pumilio Nathorst
Pseudocycas steenstrupi (Heer) Nathorst
Pteris ? albertsii Dunker
Pteris frigida Heer
Pteris grönlandica Heer
Pteris longipennis Heer
Pterospermites auriculatus Heer
Pterospermites cordifolius Heer [1]
Quercus ferox Heer
Quercus (Dryophyllum) hieracifolia (Debey) Hosius and v. d. Marck
Quercus rinkiana Heer
Quercus thulensis Heer
Quercus troglodytis Heer
Quercus warmingiana Heer
Quercus westfalica Hosius and v. d. Marck
Rhamnus acuta Heer

[1] Recently referred to *Nuphar* by Fritel, Bull. Soc. Géol. Fr. (iv), t. xiii, pp. 293-297, 1913.

Rhamnus örstedi Heer
Rhytisma hederæ Heer
Sapindus morrisoni Heer
Sapindus prodromus Heer
Sassafras arctica Heer
Sassafras (Araliopsis) recurvatum Lesq.
Sciadopitytes nathorsti Halle[1]
Selaginella arctica Heer
Sequoia ambigua Heer
Sequoia fastigiata (Sternberg) Heer
Sequoia reichenbachi (Geinitz) Heer
Sequoia rigida Heer
Sequoia subulata Heer
Sparganium cretaceum Heer
Tetraphyllum oblongum Heer
Thuja cretacea (Heer) Newberry
Thuites meriani Heer
Thuites pfaffii Heer
Widdringtonites reichii (Ettingshausen) Heer
Widdringtonites subtilis Heer
Williamsonia cretacea Heer
Xylomites aggregatus Heer
Zingiberites pulchellus Heer

There is no need to attempt a botanical analysis of this flora since it has been fully discussed by Heer.[2] It is, however, of very great importance from the standpoint of correlation. Fourteen ferns and conifers range up into the Atane beds from the older Kome series and 34 species continue upward into the Patoot series. Compared with North American Upper Cretaceous floras it is seen to contain 3 Washita species (the Washita flora has never been studied), 15 Tuscaloosa species, 14 Black Creek species, 47 Raritan species, 37 Magothy species, and 36 Dakota species. Compared with European Upper Cretaceous floras it has 22 species in the Perucer beds of Bohemia and Moravia (Cenomanian), 14 at Niederschœna in Saxony (Cenomanian), 6 in the Turonian and 5 each at Aachen and in the Westphalian Cretaceous.

The very large number of definitely determined Cenomanian species altogether precludes its reference to the Emscherian, as some students

[1] Halle, T. G., Geol. Fören. Forhandl. Bd. xxxvii, 1915, p. 512, pl. xii, figs. 16-29.

[2] Heer, Fl. Foss. Arct., Bd. vii, 1883, pp. 157-207.

have advocated, and greatly strengthens Heer's contention that it is of Cenomanian age, although it may extend upward into the Turonian.

The Patoot Series

The lithology of the Patoot series, differentiated by Heer on paleobotanical grounds, is similar to that at Ata except for the greater number of "burnt" layers. The lower 500 feet of the section at Patoot referred to the Atane series by Heer extends upward without any apparent lithological break to a height of 2600 feet where there is a sandstone series about 300 feet thick which may be of Tertiary age. White and Schuchert suggest that the Patoot series represent transition beds between the Atane series and the Tertiary.

The recorded flora consists of the following species:

Acer caudatum Heer
Acer edentatum Heer
Acerates arctica Heer
Adiantum densinerve Heer
Alnus protogæa Heer
Aralia waigattensis Heer
Arundo groenlandica Heer
Asplenium (Benizia) calopteris Debey and Ettingshausen
Asplenium pingelianum Heer
Asplenium scrobiculatum Heer
Betula atavina Heer
Betula tremula Heer
Betula vetusta Heer
Carpinites microphyllus Heer
Carpolithes longipes Heer
Carpolithes patootensis Heer
Cassia ettingshauseni Heer
Ceanothus prodromus Heer
Celastrophyllum crenatum Heer
Celastrophyllum lanceolatum Ettingshausen
Celastrophyllum serratum Saporta and Marion
Celastrus arctica Heer
Cephalotaxites insignis Heer
Cinnamomum ellipsoideum Saporta and Marion
Cinnamomum newberryi Berry
Cissites affinis Lesq.
Colutea protogæa Heer
Comptonia microphylla (Heer) Berry

Cornus holmiana Heer
Cornus thulensis Heer
Cratægus atavina Heer
Cratægus ? fragarioides Heer
Cunninghamites elegans (Corda) Endlicher
Cyathea angusta Heer
Cyparissidium gracile Heer
Cyparissidium mucronatum Heer
Dammara macrosperma Heer
Dammara microlepis Heer
Dewalquea groenlandica Heer
Dewalquea haldemiana (Debey) Saporta and Marion
Dewalquea insignis Hosius and von der Marck
Dicksonia grönlandica Heer
Dicksonia (Protopteris) punctata (Sternberg) Heer
Diosypros primæva Heer
Diospyros steenstrupi Heer
Diphyllites membranaceus Heer
Dryopteris örstedi (Heer) Knowlton
Equisetum amissum Heer
Ficus ? arctica Heer
Ficus atavina Heer
Fraxinus præcox Heer
Geinitzia hyperborea Heer
Gleichenia giesekiana Heer
Gleichenia gracilis Heer
Gleichenia vahliana Heer
Glyptostrobus intermedius Heer
Hedera cuneata Heer
Hedera macclurei Heer ?
Ilex borealis Heer
Ilex patootensis Heer
Inolepsis affinis Heer
Juglans crassipes Heer
Kaidacarpum cretaceum Heer
Laurus atanensis Berry
Laurus hollæ Heer
Laurus plutonia Heer
Leguminosites dentatus Heer
Leguminosites frigidus Heer
Leguminosites orbiculatus Heer
Leguminosites patootensis Heer
Macclintockia cretacea Heer
Majanthemophyllum cretaceum Heer
Majanthemophyllum lanceolatum Heer
Majanthemophyllum pusillum Heer
Moriconia cyclotoxon Debey and Ettingshausen
Myrica longa Heer

Myrica præcox Heer
Ophioglossum granulatum Heer (probably same as *Pinus granulatum* of the Raritan)
Osmunda arctica Heer
Paliurus affinis Heer
Panax globulifera Heer
Panax macrocarpa Heer
Pecopteris bohemica Corda
Phegopteris grothiana Heer
Phegopteris kornerupi Heer
Pinus quenstedti Heer
Planera antiqua Heer
Platanus affinis Heer
Platanus asperaformis Berry
Platanus newberryana Heer
Polypodium graahianum Heer
Populus denticulata Heer
Populus stygia Heer
Potamogeton cretaceus Heer
Pteris longipennis Heer
Quercus cuspidigera Heer
Quercus denticulata Heer
Quercus johnstrupi Heer
Quercus langeana Heer
Quercus marioni Heer
Quercus myrtillus Heer
Quercus patootensis Heer
Raphaelia neuropteroides Debey and Ettingshausen
Rhamnus pfaffiana Heer
Sapindus morrisoni Heer
Sapotacites hyperboreus Heer
Sapotacites nervillosus Heer
Sapotacites retusus Heer (referred to *Liriodendropsis* by Hollick)
Sassafras pfaffiana Heer
Sequoia concinna Heer
Sequoia fastigiata (Sternberg) Heer
Sequoia heterophylla Velenovsky
Sequoia macrolepis Heer
Sequoia rigida Heer
Sphæria cretacea Heer
Sterculia variabilis Saporta
Tæniopteris deperdita Heer
Taxites pecten Heer
Viburnum attenuatum Heer
Viburnum multinerve Heer
Viburnum zyziphoides Heer
Widdringtonites reichii (Ettingshausen) Heer
Zizyphus groenlandicus Heer

This flora contains 20 Dakota species, 22 Raritan species, 19 Magothy species, 8 Tuscaloosa species and 4 Black Creek species. There are 11 species common to the Perucer beds of Bohemia and Moravia, 6 to Niederschœna, 7 to the European Turonian, 3 to Aachen and 3 to the Westphalian Cretaceous (Campanian). Four have been identified in the Montian of Europe.

The large number of Atane species present (thirty-four) as well as the numerous Dakota, Raritan and Magothy species preclude considering the flora as young as, for example, the Laramie. It is singular if the Patoot flora is younger than the Emscherian that it should have so much more in common with the Cenomanian and Turonian floras than with the extensive Lower (Campanian) and Upper (Maestrichtian) Aturian floras so extensively developed in north Germany. On the other hand, the four Montian species are not without significance. It is possible that several horizons of the Upper Cretaceous are represented.

THE ATLANTIC COASTAL PLAIN

MARTHAS VINEYARD TO THE DISTRICT OF COLUMBIA

This area includes traces of former Cretaceous sediments on the shores of Massachusetts Bay; the remains of such sediments preserved in place or for the most part in morainic material along the islands of the south shore of New England and including Marthas Vineyard, Block Island, and numerous localities throughout the extent of Long Island; Staten Island; and a belt of territory extending southwestward across New Jersey, Delaware, and Maryland to the Potomac River.

The accessibility of these areas to large centers of scientific activity and the economic importance and exploitation of the clay and sand areas of the Amboy district in New Jersey have resulted in an enormous literature, going back as early as the beginning of the eighteenth century and which cannot be cited in a chapter like the present. Fossil plants from Marthas Vineyard were figured by Edward Hitchcock as early as 1841, and Conrad in 1869 described a *Podozamites* from the New Jersey Raritan. The chief contributors to the paleobotany of this area have been Newberry, Hollick, and the writer. Newberry's pioneer work related chiefly to the Amboy

district of New Jersey and resulted in several preliminary papers and a final monograph[1] published posthumously in 1896 and devoted primarily to the flora of deposits now known as the Raritan formation, in which one hundred and fifty-six species were described. Subsequent collections resulted in the publication of "The Flora of the Raritan Formation" by the writer[2] in 1911. In this work, which is complete for the Raritan formation of the New Jersey area, the geology and the flora are fully described and the antecedent literature is cited in detail.

The work of Hollick has been almost entirely confined to the area from Staten Island eastward. A long series of minor contributions commencing in 1892 culminated in a handsome monograph[3] published in 1907 in which all of the previous literature is fully quoted. Subsequently this author has published an account[4] of additions to this flora, and in collaboration with E. C. Jeffrey has given an elaborate account[5] of the important structural coniferous material contained in the Raritan formation on Staten Island. Jeffrey and a number of his students have also published in recent years several minor papers on structural material from this general region.[6]

[1] Newberry, J. S., The Flora of the Amboy Clays, Mon. U. S. Geol. Survey, vol. xxvi, 1895.

[2] Berry, E. W., Bull. 3, Geol. Survey N. J., 1911.

[3] Hollick, A., The Cretaceous Flora of Southern New York and New England. Mon. U. S. Geol. Survey, vol. l, 1906.

[4] Hollick, A., Mem. N. Y. Bot. Garden.

[5] Hollick & Jeffrey, Studies of Cretaceous Coniferous Remains from Kreischerville, New York. Mem. N. Y. Bot. Garden, vol. iii, 1909.

[6] Jeffrey, E. C., A New Prepinus from Marthas Vineyard. Proc. Boston Soc. Nat. Hist., vol. xxxiv, 1910, pp. 333-338, pl. xxxiii.

——— The Affinities of Geinitzia gracillima. Bot. Gaz., vol. l, 1911, pp. 21-27, pl. viii.

Bailey, I. W., A Cretaceous Pityozylon with marginal tracheides. Ann. Bot., vol. xxv, 1911, pp. 315-325, pl. xxvi.

Holden, R., Cretaceous Pityoxyla from Cliffwood, New Jersey. Proc. Amer. Acad. Arts and Sci., vol. xlviii, 1913, pp. 609-623, pls. i-iv.

——— Contributions to the Anatomy of Mesozoic Conifers. No. 2. Cretaceous Lignites from Cliffwood, New Jersey. Bot. Gaz., vol. lviii, 1914, pp. 168-177, pls. xii, xv.

Jeffrey, E. C., On the Structure of the Leaf in Cretaceous Pines. Ann. Bot., vol. xxii, 1908, pp. 207-220, pls. xiii, xiv.

Sinnott, G. W., Paracedroxylon, a New Type of Araucarian Wood. Rhodora, vol. xi, pp. 165-173, pls. lxxx-lxxxi.

The Raritan formation is overlain unconformably from Marthas Vineyard to the Potomac River by the sands and lignitic clays of the Magothy formation. A few Magothy species were included in Newberry's Amboy Clay monograph. No general work has hitherto appeared and the Magothy flora is described in a large number of small papers commencing with one by Hollick[1] in 1897. With this exception these contributions have nearly all been made by the writer.[2]

Since the geology, literature and relationship of these floras are fully discussed elsewhere in the present volume, these subjects will not be further referred to in this chapter.

There follow complete lists of the Raritan and Magothy floras as represented throughout the extent of these formations.

[1] Hollick, A., The Cretaceous Clay Marl Exposure at Cliffwood, New Jersey. Trans. N. Y. Acad. Sci., vol. xvi, 1897, pp. 124-137, pls. xi-xiv.

[2] Berry, E. W., The Flora of the Matawan Formation. Bull. N. Y. Bot. Garden, vol. iii, 1903, pp. 45-103, pls. xliii-lvii.

——— New Species of plants from the Matawan Formation. Amer. Nat., vol. xxxvii, 1903, pp. 677-684, tf. 1-8.

——— The Cretaceous Exposure near Cliffwood, N. J. Amer. Geol., vol. xxxiv, 1904, pp. 253-260, pl. xv.

——— Fossil Grasses and Sedges. Amer. Nat., vol. xxxix, 1905, pp. 345-348, tf. 1.

——— An Old Swamp Bottom. Torreya, vol. v, 1905, pp. 179-182.

——— Additions to the flora of the Matawan Formation. Bull Torrey Bot. Club, vol. xxxi, 1904, pp. 67-82, pl. i-v.

——— Additions to the fossil flora from Cliffwood, N. J. *Ibid.*, vol. xxxii, 1905, pp. 43-48, pls. i, ii,

——— A palm from the mid-Cretaceous. Torreya, vol. v, 1905, pp. 30-33.

——— A Ficus confused with Proteoides. Bull. Torrey Bot. Club, vol. xxxii, 1905, pp. 327-330, pl. xxi.

——— The Flora of the Cliffwood Clays. Ann. Rept. State Geol. N. J. for 1905, pp. 135-172, pls. xix-xxvi.

——— Contributions to the Mesozoic flora of the Atlantic Coastal Plain I. Bull. Torrey Bot. Club, vol. xxxiii, 1906, pp. 163-182, pls. vii-ix; IV. *Ibid.*, vol. xxxvii, 1910, pp. 19-29, pl. viii; VII. *Ibid.*, vol. xxxviii, 1911, pp. 399-424, pls. xviii-xix; X. *Ibid.*, vol. xli, 1914, pp. 295-300.

——— Fossil Plants along the Chesapeake and Delaware Canal. Jour. N. Y. Bot. Garden, vol. vii, 1906, pp. 5-7.

——— New species of plants from the Magothy Formation. J. H. U. Circ. n. s., No. 7, 1907, pp. 82-89, tf. 1-5.

——— A new Cretaceous Bauhinia. Torreya, vol. viii, 1908, pp. 218-219, tf. 1-3.

The Raritan Flora

Acer amboyense Newberry
Acer minutum Hollick
Acerates amboyense Berry
Andromeda cookii Berry
Andromeda grandifolia Berry
Andromeda novæ-cæsareæ Hollick
Andromeda parlatorii Heer
Andromeda tenuinervis Lesquereux
Androvettia statenensis Hollick and Jeffrey
Anomaspis hispida Hollick and Jeffrey
Anomaspis tuberculata Hollick and Jeffrey
Aralia formosa Heer
Aralia groenlandica Heer
Aralia newberryi Berry
Aralia patens Hollick
Aralia quinquepartita Lesquereux
Aralia rotundiloba Newberry
Aralia washingtoniana Berry
Aralia wellingtoniana Lesquereux
Araliopsoides breviloba Berry
Araliopsoides cretacea (Newberry) Berry
Araliopsoides cretacea dentata (Lesquereux) Berry
Araliopsoides cretacea salisburraefolia (Lesquereux) Berry
Araucariopitys americana Jeffrey
Araucarioxylon noveboracense Hollick and Jeffrey
Aspidiophyllum trilobatum Lesquereux
Asplenium dicksonianum Heer
Asplenium fœrsteri Debey and Ettingshausen
Asplenium jerseyensis Berry
Asplenium raritanensis Berry
Baiera incurvata Heer
Bauhinia cretacea Newberry
Bauhinia gigantea Newberry
Brachyoxylon notabile Hollick and Jeffrey
Brachyphyllum macrocarpum Newberry
Caesalpinia cookiana Hollick
Caesalpinia raritanensis Berry
Calycites diospyriformis Newberry
Calycites parvus Newberry
Carpolithus euonymoides Hollick
Carpolithus floribundus Newberry
Carpolithus hirsutus Newberry
Carpolithus ovæformis Newberry
Carpolithus pruniformis Newberry
Carpolithus vaccinioides Hollick

Carpolithus woodbridgensis Newberry
Celastrus artica Heer
Celastrophyllum brittonianum Hollick
Celastrophyllum crenatum Heer
Celastrophyllum cretaceum Lesquereux
Celastrophyllum decurrens Lesquereux
Celastrophyllum grandifolium Newberry
Celastrophyllum minus Hollick
Celastrophyllum newberryanum Hollick
Celastrophyllum spatulatum Newberry
Celastrophyllum undulatum Newberry
Chondrites flexuosus Newberry
Chondrophyllum obovatum Newberry
Chondrophyllum orbiculatum Heer
Chondrophyllum reticulatum Hollick
Cinnamomum newberryi Berry
Cissites formosus Heer
Cissites newberryi Berry
Citrophyllum aligerum (Lesquereux) Berry
Cladophlebis socialis (Heer) Berry
Colutea primordialis Heer
Comptonia microphylla (Heer) Berry
Cordia apiculata (Newberry) Berry
Cornophyllum vetustum Newberry
Cycadinocarpus circularis Newberry
Cyparissidium gracile Heer?
Czekanowskia capillaris Newberry
Dactyolepis cryptomerioides Hollick and Jeffrey
Dammara borealis Heer
Dammara minor Hollick
Dalbergia apiculata Newberry
Dalbergia hyperborea Heer?
Dewalquea groenlandica Heer
Dewalquea insignis Hosius and von der Marck ?
Dewalquea trifoliata Newberry
Dicksonia groenlandica Heer
Diospyros amboyensis Berry
Diospyros apiculata Lesquereux ?
Diospyros primæva Heer
Diospyros vera Berry
Eucalyptus angusta Velenovsky
Eucalyptus attenuata Newberry
Eucalpytus geinitzi Heer
Eucalyptus linearifolia Berry
Eucalyptus parvifolia Newberry
Eugeinitzia proxima Hollick and Jeffrey
Ficus daphnogenoides (Heer) Berry

Ficus krausiana Heer
Ficus myricoides Hollick
Ficus ovatifolia Berry
Ficus woolsoni Newberry
Fontainea grandifolia Newberry
Frenelopsis hoheneggeri (Ettingshausen) Schenk
Geinitzia formosa Heer
Geinitzia reichenbachi Hollick and Jeffrey
Gleichenia giesekiana Heer
Gleichenia micromera Heer
Gleichenia zippei Heer
Hedera obliqua Newberry
Hedera primordialis Saporta
Hymenæa dakotana Lesquereux
Ilex amboyensis Berry
Ilex elongata Newberry
Juglans arctica Heer
Juglans crassipes Heer
Juniperus hypnoides Heer
Kalmia brittoniana Hollick
Laurophyllum angustifolium Newberry
Laurophyllum elegans Hollick
Laurophyllum lanceolatum Newberry
Laurophyllum minus Newberry
Laurophyllum nervillosum Hollick
Laurus hollæ Heer?
Laurus nebrascensis Hollick
Laurus plutonia Heer
Leguminosites atanensis Heer
Leguminosites coronilloides Heer
Leguminosites omphalobioides Lesquereux
Leguminosites raritanensis Berry
Liriodendron oblongifolium Newberry
Liriodendron primævum Newberry
Liriodendron quercifolium Newberry
Liriodendropsis angustifolia Newberry
Liriodendropsis retusa (Heer) Newberry
Liriodendropsis simplex Newberry
Majanthemophyllum pusillum Heer
Magnolia alternans Heer
Magnolia boulayana Lesquereux
Magnolia hollicki Berry
Magnolia isbergiana Heer ?
Magnolia lacœana Lesquereux
Magnolia longipes Hollick
Magnolia newberryi Berry
Magnolia speciosa Heer

Magnolia woodbridgensis Hollick
Menispermites borealis Heer
Menispermites wardianus Hollick
Microzamia gibba (Reuss) Corda
Moriconia cyclotoxon Debey and Ettingshausen
Myrica acuta Hollick
Myrica cinnamomifolia Newberry
Myrica davisii Hollick
Myrica emarginata Heer
Myrica fenestrata Newberry
Myrica hollicki Ward
Myrica newberryana Hollick
Myrica raritanensis Hollick
Myrsine borealis Heer
Myrsine gaudini (Lesquereux) Berry
Myrsine oblongata Hollick
Newberryana rigida (Newberry) Berry
Paliurus affinis Heer ?
Passiflora antiqua Newberry
Persoonia lesquereuxii Knowlton
Persoonia spatulata Hollick
Phaseolites elegans Hollick
Phaseolites manhassettensis Hollick
Phegopteris grothiana Heer
Phyllites poinsettioides Hollick
Phyllites trapaformis Berry
Pinus granulata (Heer) Stopes
Pinus quinquefolia Hollick and Jeffrey
Pinus raritanensis Berry
Pinus tetraphylla Jeffrey
Pinus triphylla Hollick and Jeffrey
Pistacia aquehongensis Hollick
Pityoidolepis statenensis Hollick and Jeffrey
Pityoxylon statenense Jeffrey and Chrysler
Planera knowltoniana Hollick
Platanus aquehongensis Hollick
Platanus heerii Lesquereux
Podozamites acuminatus Hollick
Podozamites knowltoni Berry
Podozamites lanceolatus (L. and H.) F. Braun
Podozamites marginatus Heer
Populus harkeriana Lesquereux
Populus orbicularis (Newberry) Berry
Prepinus statenensis Jeffrey
Protodammara speciosa Hollick and Jeffrey
Protophyllocladus subintegrifolius (Lesquereux) Berry
Protophyllum multinerve Lesquereux

Protophyllum sternbergii Lesquereux
Prunus ? acutifolia Newberry
Pseudogeinitzia sequoiiformis Hollick and Jeffrey
Pterospermites modestus Lesquereux
Pterospermites obovatus (Newberry) Berry
Quercus? novæ-cæsareæ Hollick·
Quercus raritanensis Berry
Raritania gracilis (Newberry) Hollick and Jeffrey
Rhamnites minor Hollick
Salix flexuosa Newberry
Salix inæqualis Newberry
Salix newberryana Hollick
Salix lesquereuxii Berry
Salix pseudo-hayei Berry
Salix raritanensis Berry
Sapindus morrisoni Heer
Sassafras acutilobum Lesquereux
Sassafras hastatum Newberry
Sassafras progenitor Hollick
? Sequoia concinna Heer
Sequoia heterophylla Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Smilax raritanensis Berry
Sphærites raritanensis Berry
Sphenaspis statenensis Hollick and Jeffrey
Strobilites davisii Hollick and Jeffrey
Strobilites microsporophorus Hollick and Jeffrey
Tricalycites major Hollick
Tricalycites papyraceus Newberry
Tricarpellites striatus Newberry
Thuya cretacea (Heer) Newberry
Thuyites meriani Heer
Viburnum integrifolium Newberry
Widdringtonites reichii (Ettingshausen) Heer
Widdringtonites subtilis Heer
Williamsonia problematica (Newberry) Ward
Williamsonia riesii Hollick
Williamsonia smockii Newberry

The Magothy Flora

Acer paucidentatum Hollick
Algites americana Berry
Amelanchier whitei Hollick
Andromeda cookii Berry
Andromeda grandifolia Berry
Andromeda novæ-cæsareæ Hollick

Andromeda parlatorii Heer
Aralia brittoniana Berry
Aralia coriacea Velenovsky
Aralia fowneri Lesquereux
Aralia groenlandica Heer
Aralia mattewanensis Berry
Aralia nassauensis Hollick
Aralia newberryi Berry
Aralia ravniana Heer
Araucaria bladenensis Berry
Araucaria marylandica Berry
Araucarites ovatus Hollick
Araucarites zeilleri Berry
Arisæma cretaceum Lesquereux
Arisæma ? mattewanense Hollick
Asplenium cecilensis Berry
Baiera grandis Heer?
Banksia pusilla Velenovsky?
Banksites saportanus Velenovsky
Bauhinia marylandica Berry
Betulites populifolius Lesquereux?
Brachyphyllum macrocarpum Newberry
Brachyphyllum macrocarpum formosum Berry
Bumelia praenuntia Berry
Calycites alatus Hollick
Calycites obovatus Hollick
Carex clarkii Berry
Carpites liriophylli Lesquereux
Carpites minutulus Lesquereux
Carpolithus cliffwoodensis Berry
Carpolithus drupæformis Berry
Carpolithus floribundus Newberry
Carpolithus hirsutus Newberry
Carpolithus juglandiformis Berry
Carpolithus mattewanensis Berry
Carpolithus ostryæformis Berry
Carpolithus septloculus Berry
Cassia insularis Hollick
Ceanothus constrictus Hollick
Celastrophyllum crassipes Lesquereux?
Celastrophyllum crenatum Heer?
Celastrophyllum elegans Berry
Celastrophyllum grandifolium Newberry?
Celastrophyllum newberryanum Hollick
Celastrophyllum undulatum Newberry?
Celastrus arctica Heer
Chondrites flexuosus Newberry?

Cinnamomum crassipetiolatum Hollick
Cinnamomum heeri Lesquereux
Cinnamomum newberryi Berry
Cinnamomum newbranaceum (Lesquereux) Hollick
Cissites formosus magothiensis Berry
Cissites newberryi Berry
Citrophyllum aligerum (Lesquereux) Berry
Coccolobites cretaceus Berry
Cocculus cinnamomeus Velenovsky
Cocculus imperfectus Hollick
Cocculus inquirendus Hollick
Cocculus minutus Hollick
Colutea obovata Berry
Confervites dubius Berry
Cordia apiculata (Newberry) Berry
Cornus cecilensis Berry
Cornus forchhammeri Heer
Cratægus monmouthensis Berry
Credneria macrophylla Heer
Crotonophyllum cretaceum Velenovsky
Cunninghamites elegans (Corda) Endlicher
Cunninghamites squamosus Heer
Cupressinoxylon bibbinsi Knowlton
Czekanowskia dichotoma Heer?
Dalbergia irregularis Hollick
Dalbergia minor Hollick
Dalbergia severnensis Berry
Dammara borealis Heer
Dammara cliffwoodensis Hollick
Dammara minor Hollick
Dammara northportensis Hollick
Dewalquea groenlandica Heer
Diospyros apiculata Lesquereux?
Diospyros primæva Heer
Diospyros prodromus Heer?
Diospyros provecta Velenovsky
Diospyros pseudoanceps Lesquereux
Diospyros rotundifolia Lesquereux
Doryanthites cretacea Berry
Dryandroides quiercinea Velenovsky
Elæodendron marylandicum Berry
Elæodendron stricum Hollick
Embothriopsis presagita Hollick
Eucalyptus ? attenuata Newberry
Eucalyptus geinitzi Heer
Eucalyptus geinitzi propinqua Hollick
Eucalyptus latifolia Hollick

Eucalyptus linearifolia Berry
Eucalyptus schubleri (Heer) Hollick
Eucalyptus wardiana Berry
Ficus atavina Heer
Ficus cecilensis Berry
Ficus crassipes Heer
Ficus daphnogenoides (Heer) Berry
Ficus krausiana Heer
Ficus krausiana subsimilis Hollick
Ficus myricoides Hollick
Ficus reticulata (Lesquereux) Knowlton
Ficus sapindifolia Hollick
Ficus willisiana Hollick
Ficus woolsoni Newberry
Frenelopsis hoheneggeri (Ettingshausen) Schenk?
Geinitzia formosa Heer
Gleichenia delawarensis Berry
Gleichenia gracilis Heer?
Gleichenia protogæa Debey and Ettingshausen
Gleichenia saundersii Berry
Gleichenia zippei (Corda) Heer
Guatteria cretacea Hollick
Gyminda primordialis Hollick
Hedera cecilensis Berry
Hedera cretacea Lesquereux
Hedera simplex Hollick
Heterofilicites anceps Berry
Hymenæa dakotana Lesquereux
Hymenæa primigenia Saporta
Ilex papillosa Lesquereux
Ilex severnensis Berry
Ilex strangulata Lesquereux
Illicium deletoides Berry
Juglans arctica Heer
Juglans crassipes Heer
Juglans elongata Hollick
Juniperus hypnoides Heer
Laurophyllum angustifolium Newberry
Laurophyllum elegans Hollick
Laurophyllum lanceolatum Newberry
Laurophyllum ocoteæoides Hollick
Laurus antecedens Lesquereux
Laurus atanensis Berry
Laurus hollæ Heer
Laurus hollickii Berry
Laurus nebrascensis Lesquereux
Laurus newberryana Hollick

Laurus plutonia Heer
Laurus proteæfolia Lesquereux
Laurus teliformis Lesquereux
Leguminosites canavalioides Berry
Leguminosites convolutus Lesquereux?
Leguminosites coronilloides Heer
Leguminosites omphalobioides Lesquereux
Ligustrum subtile Hollick
Liriodendron attenuatum Hollick
Liriodendron morganensis Berry
Liriodendron oblongifolium Newberry?
Liriodendropsis angustifolia Newberry
Liriodendropsis constricta Hollick
Liriodendropsis retusa (Heer) Hollick
Liriodendropsis simplex Newberry
Liriodendropsis spectabilis Hollick
Lycopodium cretaceum Berry
Magnolia amplifolia Heer
Magnolia boulayana Lesquereux
Magnolia capellinii Heer
Magnolia hollicki Berry
Magnolia isbergiana Heer
Magnolia lacœana Lesquereux
Magnolia longipes Hollick
Magnolia obtusata Heer
Magnolia pseudoacuminata Lesquereux
Magnolia speciosa Heer
Magnolia tenuifolia Lesquereux
Magnolia vaningeni Hollick
Magnolia woodbridgensis Newberry
Malapoenna falcifolia (Lesquereux) Knowlton
Marsilia andersoni Hollick
Menispermites acutilobus Lesquereux?
Menispermites brysoniana Hollick
Microzamia ? dubia Berry
Moriconia americana Berry
Myrica brittoniana Berry
Myrica cliffwoodensis Berry
Myrica longa Heer
Myrica zenkeri (Ettingshausen) Velenovsky
Myrsine borealis Heer
Myrsine crassa Lesquereux
Myrsine gaudini (Lesquereux) Berry
Myrtophyllum sapindoides Hollick
Nectandra imperfecta Hollick
Nelumbo kempii Hollick
Nelumbo primæva Berry
Ocotea nassauensis Hollick

Onoclea inquirenda Hollick
Osmunda delawarensis Berry
Osmunda novæ-cæsareæ Berry
Paliurus integrifolius Hollick
Paliurus populiferus Berry
Palmoxylon cliffwoodensis Berry [1]
Panax cretacea Heer
Periploca cretacea Hollick
Persea leconteana Lesquereux
Persea valida Hollick
Phaseolites manhassettensis Hollick
Phragmites ? cliffwoodensis Berry
Phyllites cliffwoodensis Berry
Picea cliffwoodensis Berry
Pinus andræi Coeymans?
Pinus delicatulus Berry
Pinus mattewanensis Berry
Pinus protoscleropitys Holden
Pistia nordenskioldi (Heer) Berry
Pitoxylon anomalum Holden
Pitoxylon foliosum Holden
Pitoxylon hollicki Knowlton
Planera betuloides Hollick
Platanus kümmeli Berry
Podozamites knowltoni Berry
Podozamites lanceolatus (L. and H.) F. Braun
Podozamites marginatus Heer
Populus stygia Heer
Populites tenuifolius Berry
Premnophyllum trigonum Velenovsky
Protodammara speciosa Hollick and Jeffrey
Protophyllocladus lobatus Berry
Protophyllocladus subintegrifolius (Lesquereux) Berry
Quercus eoprinoides Berry
Quercus hollickii Berry
Quercus holmesii Lesquereux
Quercus morrisoniana Lesquereux
Quercus ? novæ-cæsareæ Hollick
Quercus severnensis Berry
Quercus sp. Berry
Raritania gracilis (Newberry) Hollick and Jeffrey
Rhamnites apiculatus Lesquereux
Rhamnus inæquilateris Lesquereux
Rhamnus novæ-cæsareæ Berry
Rhus cretacea Heer?
Sabalites magothiensis Berry

[1] Berry, E. W., Amer. Jour. Sci. (IV), vol. xli, 1916, pp. 193-197.

Sagenopteris variabilis Velenovsky
Salix flexuosa Newberry
Salix lesquereuxii Berry
Salix mattewanensis Berry
Salix meekii Newberry
Salix purpuroides Hollick
Sapindus apiculatus Velenovsky?
Sapindus imperfectus Hollick
Sapindus morrisoni Heer
Sapotacites knowltoni Berry
Sassafras acutilobum Lesquereux
Sassafras angustilobum Hollick
Sassafras progenitor Newberry
Sequoia ambigua Heer
Sequoia concinna Heer
Sequoia fastigiata (Sternberg) Heer?
Sequoia gracilis Heer?
Sequoia heterophylla Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Smilax raritanensis Berry?
Sphærites raritanensis Berry
Sterculia cliffwoodensis Berry
Sterculia minima Berry
Sterculia prelabrusca Hollick
Sterculia snowii Lesquereux?
Sterculia snowii bilobatum Berry
Sterculia sp. Hollick
Strobilites inquirendus Hollick
Strobilites perplexus Hollick
Thuja cretacea (Heer) Newberry
Thyrsopteris grevilleoides (Heer) Hollick
Tricalycites major Hollick
Tricalycites papyraceus Newberry
Tricarpellites striatus Newberry
Viburnum hollickii Berry
Viburnum integrifolium Newberry
Viburnum mattewanensis Berry
Widdringtonites fasciculatus Hollick
Widdringtonites reichii (Ettingshausen) Heer
Widdringtonites subtilis Heer
Williamsonia delawarensis Berry
Williamsonia marylandica Berry
Williamsonia problematica (Newberry) Ward
Zizyphus cliffwoodensis Berry
Zizyphus elegans Hollick
Zizyphus groenlandicus Heer
Zizyphus lewisiana Hollick?
Zizyphus oblongus Hollick

The marine sediments of the Matawan formation which overlie those of the Magothy are frequently lignitic with associated amber, but identifiable plants are very rare. *Ficus matawanensis* Berry has been described from the Woodbury clays of New Jersey,[1] and *Dammara cliffwoodensis* Hollick has been found in Matawan beds in Maryland.[1]

The only plants recorded from the still younger Monmouth formation are the petrified remains of a palm described by Stevens[2] from Atlantic Highlands, New Jersey, as *Palmoxylon*.

Throughout the state of Virginia the Upper Cretaceous deposits are deeply buried by the widespread transgression of the Eocene, and no fossil plants have ever been collected, although traces of Upper Cretaceous invertebrates and lignite have been encountered in deep borings. South of Virginia the Upper Cretaceous again reaches the surface in the North Carolina area.

NORTH CAROLINA

The presence of Upper Cretaceous deposits in North Carolina has long been known, although as was usually the case, the earlier students confined their attention chiefly to the strictly marine beds containing invertebrate fossils. Although petrified wood and lignite were mentioned as early as 1827 (Olmsted) no identifiable remains of plants were discovered until the inauguration in 1906 of the co-operative investigation of the Coastal Plain of North Carolina, in which the writer collaborated. In this and subsequent years fossil plants were discovered at numerous localities and were the basis of publication of several minor papers[3] which contain all that has been printed regarding the Upper Cretaceous flora. This flora comes from the Black Creek formation, which is fully described

[1] Berry, E. W., Bull. Torrey Bot. Club, vol. xxxviii, 1911, pp. 399-400.

[2] Stevens, N. E., A Palm from the Upper Cretaceous of New Jersey. Amer. Jour. Sci. (iv), vol. xxxiv, 1912, pp. 421-436, tf. 1-24.

[3] Berry, E. W., Bull. Torrey Bot. Club, vol. xxxiv, 1907, pp. 185-206, pls. xi-xvi; Johns Hopkins Univ. Circ., n. s., 1907, No. 7, pp. 79-91; Bull. Torrey Bot. Club, vol. xxxv, 1908, pp. 249-260, pls. xi-xvi; Amer. Jour. Sci. (iv), vol. xxv, 1908, pp. 382-386; Bull. Torrey Bot. Club. vol. xxxvii, 1910, pp. 181-200, pls. xix-xxiv.

in the recent work on the Coastal Plain of North Carolina.[1] The following species have been determined:

Acerates amboyense Berry
Algites americana Berry
Andromeda grandifolia Berry
Andromeda novæ-cæsareæ Hollick
Andromeda parlatorii Heer
Androvettia carolinensis Berry
Araucaria bladenensis Berry
Araucaria clarki Berry
Araucaria jeffreyi Berry
Aristolochites sp.
Brachyphyllum macrocarpum Newberry
Carpolithus bladenensis Berry
Celastrophyllum crenatum Heer
Celastrophyllum undulatum Newberry
Cephalotaxospermum carolinianum Berry
Cinnamomum heerii Lesquereux
Citrophyllum aligerum (Lesquereux) Berry
Cornophyllum sp.
Cunninghamites elegans (Corda) Endlicher
Cycadinocarpus circularis Newberry
Dammara borealis Heer
Dewalquea grönlandica Heer
Diospyros primæva Heer
Doryanthites cretacea Berry
Eucalyptus attenuata Newberry
Eucalyptus geinitzi (Heer) Heer
Eucalyptus linearifolia Berry
Ficus crassipes Heer
Ficus daphnogenoides (Heer) Berry
Ficus fructus
Ficus inæqualis Lesquereux
Ficus ovatifolia Berry
Ficus stephensoni Berry
Gleditsiaphyllum triacanthoides Berry
Hedera primordialis Saporta
Juglans arctica Heer
Kalmia brittoniana Hollick?
Laurophyllum elegans Hollick
Leguminosites robiniifolia Berry
Liriodendron sp.
Liriodendron dubium Berry
Liriodendron cf. *primævum* Newberry

[1] N. C. Geol. & Econ. Survey, vol. ii, 1912, pp. 111-145, 306-314.

Magnolia capellinii Berry
Magnolia newberryi Berry
Malapoenna horrellensis Berry
Manihotites georgiana Berry
Menispermites sp.
Moriconia americana Berry
Myrica cliffwoodensis Berry
Myrica elegans Berry
Myrsine borealis Heer
Myrsine gaudini (Lesquereux) Berry
Phaseolites formus Lesquereux
Phragmites pratti Berry
Pinus raritanensis Berry
Pisonia cretacea Berry
Pistia nordenskioldi (Heer) Berry
Planera cretacea Berry
Podozamites knowltoni Berry
Podozamites lanceolatus (L. and H.) F. Braun
Pterospermites carolinensis Berry
Pterospermites crednerafolia Berry
Quercus pratti Berry
Quercus pseudowestfalica Berry?
Salix eutawensis Berry
Salix flexuosa Newberry
Salix lesquereuxii Berry
Salix newberryana Hollick
Sassafras acutilobum Lesquereux
Sequoia heterophylla Velenovsky
Sequoia minor Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Tumion carolinianum Berry

SOUTH CAROLINA

Although Cretaceous deposits were recognized by Vanuxem in South Carolina as early as 1829, here again it was the fossiliferous marine beds which were recognized, and the initial deposits of the Upper Cretaceous cycle of sedimentation, partially continental in character, were referred to the Eocene for a generation or more after Vanuxem's day.

The presence of fossil plants in this state was announced by the writer[1] in 1907, and four years later[2] the general character of this flora was

[1] Berry, E. W., Johns Hopkins Univ. Circ., n. s., 1907, No. 7, pp. 79-91.
[2] Berry, E. W., Bull. Torrey Bot. Club, vol. xxxviii, 1911, pp. 419-424.

discussed. It is contained in initial Upper Cretaceous deposits termed the Middendorf arkose member, that are partially contemporaneous with the deposits of the Black Creek formation which extends into the state from the North Carolina area and which also contains fossil plants. The geology and floras have recently been described in detail by the writer.[1] The floras clearly constitute a single floral unit which is made up of the following species:

Acaciaphyllites grevilleoides Berry
Algites americana Berry
Andromeda euphorbiophylloides Berry
Andromeda grandifolia Berry
Andromeda novæ-cæsareæ Hollick
Andromeda parlatorii Heer
Araucaria bladenensis Berry
Araucaria darlingtonensis Berry
Araucaria jeffreyi Berry
Arundo groenlandica Heer
Brachyphyllum macrocarpum Newberry
Cæsalpinia middendorfensis Berry
Calycites middendorfensis Berry
Carex clarkii Berry
Celastrophyllum carolinensis Berry
Celastrophyllum crenatum Heer
Celastrophyllum elegans Berry
Cephalotaxospermum carolinianum Berry
Cinnamomum middendorfensis Berry
Cinnamomum newberryi Berry
Citrophyllum aligerum (Lesquereux) Berry
Crotonophyllum panduræformis Berry
Cunninghamites elegans (Corda) Endlicher
Dewalquea smithi Berry
Diospyros primæva Heer
Diospyros rotundifolia Lesquereux
Eucalyptus angusta Velenovsky
Eucalyptus geinitzi (Heer) Heer
Eucalyptus wardiana Berry?
Ficus atavina Heer
Ficus celtifolius Berry
Ficus crassipes Heer
Ficus krausiana Heer
Ficus stephensoni Berry
Hamamelites ? cordatus Lesquereux

[1] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, 1914, pp. 5-98, pls. i-xiv.

Hedera primordialis Saporta
Heterolepis cretaceus Berry
Illicium watereensis Berry
Juglans arctica Heer
Laurus atanensis Berry
Laurus plutonia Heer
Laurophyllum elegans Hollick
Laurophyllum nervillosum Hollick
Leguminosites middendorfensis Berry
Leguminosites robiniifolia Berry
Lycopodium cretaceum Berry
Magnolia capellinii Heer?
Magnolia newberryi Berry?
Magnolia obtusata Heer
Magnolia tenuifolia Lesquereux?
Momisia carolinensis Berry
Moriconia americana Berry
Myrica brittoniana Berry
Myrica elegans Berry
Myrsine gaudini (Lesquereux) Berry
Onoclea inquirenda (Hollick) Hollick
Pachystima ? cretacea Berry
Phragmites pratti Berry
Pinus raritanensis Berry
Podozamites knowltoni Berry
Potamogeton middendorfensis Berry
Proteoides lancifolius Heer
Proteoides parvula Berry
Protophyllocladus lobatus Berry
Quercus pseudo-westfalica Berry
Quercus sumterensis Berry
Rhus darlingtonensis Berry
Sabalites carolinensis Berry
Salix flexuosa Newberry
Salix lesquereuxii Berry
Salix pseudo-hayei Berry
Salix sloani Berry
Sapindus morrisoni Heer
Sequoia reichenbachii (Geinitz) Heer
Strobilites anceps Berry
Widdringtonites subtilis Heer

GEORGIA

Although Cretaceous deposits have long been recognized in Georgia, it is only within the last few years that they have been differentiated and

precisely correlated with beds in adjacent states.[1] The first record of fossil plants is an incidental reference by the late D. W. Langdon[2] to their occurrence at Chimney Bluff, on the Chattahoochee River. A brief note on the Cretaceous flora of Georgia was published by the writer[3] in 1910, and a complete account appeared four years later.[4] Several horizons are represented. A considerable flora has been described from different localities in the Eutaw formation, considered by the writer to correspond with a part of the Black Creek formation of the Carolinas and to be of Turonian age. The following species have been recorded:

Andromeda cretacea Lesquereux ?
Andromeda wardiana Lesquereux
Androvettia elegans Berry
Aralia eutawensis Berry
Araucaria bladenensis Berry
Araucaria jeffreyi Berry
Brachyphyllum macrocarpum formosum Berry
Cinnamomum heerii Lesquereux ?
Cinnamomum newberryi Berry
Eucalyptus angusta Velenovsky
Ficus crassipes Heer
Ficus krausiana Heer
Ficus ovatifolia Berry
Juglans arctica Heer ?
Magnolia boulayana Lesquereux
Magnolia capellinii Heer
Malapoenna horrellensis Berry
Manihotites georgiana Berry
Menispermites variabilis Berry
Paliurus upatoiensis Berry
Phragmites pratti Berry
Salix eutawensis Berry
Salix flexuosa Newberry
Salix lesquereuxii Berry
Sequoia reichenbachi (Geinitz) Heer
Tumion carolinianum Berry ?
Zizyphus laurifolius Berry

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[1] Stephenson, L. W., Cretaceous. Bull. 26, Geol. Survey Ga., 1911, pp. 66-215.
——— Cretaceous Deposits of the Eastern Gulf Region. Prof. Paper U. S. Geol. Survey, No. 81, 1914, pp. 9-40, tables 1-9.

[2] Langdon, D. W., in Rept. on Geol. of Coastal Plain of Ala., 1894, p. 440.

[3] Berry, E. W., Bull. Torrey Bot. Club, vol. xxxvii, 1910, pp. 503-511, 2 tf.

[4] ——— The Upper Cretaceous Flora of Georgia. Prof. Paper U. S. Geol. Survey, No. 84, 1914, pp. 99-128, pl. xv-xxiv.

The Ripley formation, a series of littoral and marine shallow-water deposits with abundant faunas, contains a meager flora probably of Emscherian age. The following species have been recorded:

Andromeda novæ-cæsareæ Hollick
Araucaria bladenensis Berry
Araucaria jeffreyi Berry
Cunninghamites elegans (Corda) Endlicher
Doryanthites cretacea Berry
Dryopterites stephensoni Berry
Eucalyptus angusta Velenovsky
Ficus georgiana Berry
Manihotites georgiana Berry

ALABAMA [1]

The presence of fossil plants in the Tuscaloosa formation of western Alabama was announced by Winchell [2] in 1856. The formation was described in detail by Smith and Johnson [3] in 1887. During the course of their work large collections were made and forwarded to Washington, and a brief list of species was drawn up in 1894 by Ward.[4] These collections did not, however, receive critical study until the writer took up the work in 1907. Large additional collections were made, resulting in a complete account of this important flora.[5] A brief abstract was published [6] in 1913. The following species are enumerated:[7]

Abietites foliosus (Fontaine) Berry
Acerates amboyensis Berry
Andromeda grandifolia Berry
Andromeda novæ-cæsareæ Hollick
Andromeda parlatorii Heer
Andromeda wardiana Lesquereux
Androvettia carolinensis Berry
Aralia cottondalensis Berry

[1] Including scattered floras from Mississippi and Tennessee.

[2] Winchell, Alex., Proc. Amer. Assoc. Adv. Sci., vol. x, 1856, p. 92.

[3] Smith, E. A., and Johnson, L. C., Bull. U. S. Geo. Survey No. 43, 1887.

[4] In Smith, E. A., Geology of the Coastal Plain in Alabama, 1894, p. 348.

[5] This is in course of publication by the U. S. Geol. Survey as a Professional Paper, entitled Upper Cretaceous Floras of the Eastern Gulf Area.

[6] Berry, E. W., Bull. Torrey Bot. Club, vol. xl, 1913, pp. 567-574.

[7] A considerable number of these will remain *nomina nuda* until after the publication of the Professional Paper referred to above.

Asplenium dicksonianum Heer
Bauhinia cretacea Newberry
Bauhinia marylandica Berry
Brachyphyllum macrocarpum formosum Berry
Calycites sexpartitus Berry
Capparites orbiculatus Berry
Capparites synophylloides Berry
Carpolithus floribundus Newberry
Carpolithus tuscaloosensis Berry
Cassia vaughani Berry
Celastrophyllum alabamensis Berry
Celastrophyllum brittonianum Hollick
Celastrophyllum carolinensis Berry
Celastrophyllum crenatum Heer
Celastrophyllum crenatum ellipticum Berry
Celastrophyllum decurrens Lesquereux
Celastrophyllum grandifolium Newberry
Celastrophyllum gymindafolium Berry
Celastrophyllum newberryanum Hollick
Celastrophyllum precrassipes Berry
Celastrophyllum shirleyensis Berry
Celastrophyllum undulatum Newberry
Cinnamomum newberryi Berry
Cissites formosus Heer
Citrophyllum aligerum (Lesquereux) Berry
Cladophlebis alabamensis Berry
Cocculus cinnamomeus Velenovsky ?
Cocculus polycarpafolius Berry
Cocculus problematicus Berry
Colutea obovata Berry
Conocarpites formosus Berry
Cordia apiculata (Hollick) Berry
Cornophyllum obtusatum Berry
Cornophyllum vetustum Newberry
Crotonophyllum panduræformis Berry
Cycadinocarpus circularis Newberry
Cyperacites sp. Hollick
Dammara borealis Heer
Dermatophyllites acutus Heer
Dewalquea smithi Berry
Dicksonia grönlandica Heer
Diospyros amboyensis Berry
Diospyros primæva Heer
Diospyros rotundifolia Lesquereux
Eorhamnidium cretaceum Berry
Eorhamnidium platyphylloides (Lesquereux) Berry
Equisetum ? sp.

Eucalyptus geinitzi (Heer) Heer
Eucalyptus latifolia Hollick
Eugenia tuscaloosensis Berry
Ficus alabamensis Berry
Ficus crassipes (Herr) Heer
Ficus daphnogenoides (Heer) Berry
Ficus fontainei Berry
Ficus inæqualis Lesquereux
Ficus krausiana Heer
Ficus shirleyensis Berry
Ficus woolsoni Newberry
Geinitzia formosa Heer
Gleichenia delicatula Heer
Grewiopsis formosa Berry
Grewiopsis tuscaloosensis Berry
Hymenæa fayettensis Berry
Ilex masoni Lesquereux
Inga cretacea Lesquereux
Juglans arctica Heer
Jungermannites cretaceus Berry
Kalmia brittoniana Hollick
Laurophyllum angustifolium Newberry ?
Laurophyllum nervillosum Hollick
Laurus plutonia Heer
Leguminosites ingafolia Berry
Leguminosites omphalobioides Lesquereux
Leguminosites shirleyensis Berry
Leguminosites tuscaloosensis Berry
Liriodendron meekii Heer
Liriodendropsis angustifolia Newberry
Liriodendropsis constricta Ward
Liriodendropsis simplex Newberry
Lycopodites tuscaloosensis Berry
Lycopodium cretaceum Berry
Magnolia boulayana Lesquereux
Magnolia capellinii Heer
Magnolia hollicki Berry
Magnolia lacœana Lesquereux
Magnolia longipes Newberry
Magnolia newberryi Berry
Magnolia obtusata Heer
Magnolia speciosa Heer
Malapoenna cottondalensis Berry
Malapoenna cretacea Lesquereux
Malapoenna falcifolia (Lesquereux) Knowlton
Marattia cretacea Velenovsky ?
Menispermites integrifolia Berry

Menispermites trilobatus Berry
Myrica dakotensis minima Berry
Myrica emarginata Heer
Myrica longa (Heer) Heer
Myrsine borealis Heer
Myrsine gaudini (Lesquereux) Berry
Myssa snowiana Lesquereux
Oreodaphne alabamensis Berry
Oreodaphne shirleyensis Berry
Palæocassia laurinea Lesquereux
Panax cretacea Heer
Persea valida Hollick
Persoonia lesquereuxii Knowlton
Persoonia lesquereuxii minor Berry
Phaseolites formus Lesquereux
Phyllites longepetiolatus Berry
Phyllites pistiaformis Berry
Pinus raritanensis Berry
Piperites tuscaloosensis Berry
Platanus asperaformis Berry
Platanus latior (Lesquereux) Knowlton
Platanus shirleyensis Berry
Podozamites marginatus Heer
Populites tuscaloosensis Berry
Populus hyperborea Heer
Proteoides conospermafolia Berry
Protodammara speciosa Hollick and Jeffrey
Protophyllocladus subintegrifolius (Lesquereux) Berry
Pterospermites carolinensis Berry
Rhamnus tenax Lesquereux
Salix flexuosa Newberry
Salix lesquereuxii Berry
Salix meekii Newberry
Sapindus morrisoni Heer
Sapindus variabilis Berry
Sapotacites ettingshauseni Berry
Sapotacites formosus Berry
Sapotacites shirleyensis Berry
Sassafras acutilobum Lesquereux
Sequoia ambigua Heer
Sequoia fastigiata (Sternberg) Heer
Sequoia heterophylla Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Sphærites alabamensis Berry
Tricalycites papyraceus Newberry
Widdringtonites reichii (Ettingshausen) Heer
Widdringtonites subtilis Heer
Zizyphus lamarensis Berry

The Tuscaloosa formation is overlain by a marine series of deposits constituting the Eutaw formation. Its basal beds contain some traces of the vegetation of the nearby land and a considerable number of such forms have already been enumerated for the Georgia region. In Alabama the following have been recorded from the Lower Eutaw:

Andromeda parlatorii Heer
Araucaria bladenensis Berry
Bauhinia alabamensis Berry
Brachyphyllum macrocarpum formosum Berry
Cephalotaxospermum carolinianum Berry
Doryanthites cretacea Berry
Eucalyptus havanensis Berry [1]
Laurus plutonia Heer
Malapoenna horrellensis Berry
Sequoia ambigua Heer
Sequoia reichenbachi (Geinitz) Heer

The Eutaw formation is succeeded by the paleobotanically unfossiliferous Selma Chalk and the latter is overlain throughout a part of the eastern Gulf area by the Ripley formation. In the Chattahoochee drainage basin and eastward in Georgia the Ripley becomes littoral in character, and a few fossil plants have already been recorded in the account of the Cretaceous floras of Georgia. Only two identifiable species are recorded from the Ripley of Alabama. These are *Bauhinia ripleyensis* Berry and *Platanus* sp. Northward in western Tennessee where the Ripley deposits are also shallow-water near-shore sands a few fossil plants have been found. These are *Myrica ripleyensis* Berry, *Sabalites* sp., and *Salix eutawensis* Berry.

TEXAS

The presence of fossil plants in the Woodbine sands along the Red River in northeastern Texas was announced by Shumard in 1868.[2] The first account of plants from these beds was published in Knowlton [3] in 1901 in Hill's great work on Texas,[4] and was based on collections made

[1] Also recorded from deposits of this age in Western Tennessee.
[2] Shumard, B. F., Trans. Acad. Sci. St. Louis, vol. ii, 1868, p. 140.
[3] Knowlton, F. H., in Hill (op. cit.), pp. 314-318, pl. xxxix.
[4] Hill, R. T., Geography and Geology of the Black and Grand Prairies. 21st Ann. Rept. U. S. Geol. Survey, pt. vii, 1901.

by Hill and Vaughan. A small collection made by Stanton and Stephenson was described by the writer[1] in 1912. The flora, while limited, indicates synchroneity with a part of the Dakota sandstone of the West, the lower Tuscaloosa of the eastern Gulf area, and the upper Raritan and Magothy of the northern Atlantic Coastal Plain. It includes the following species:

Andromeda novæ-cæsareæ Hollick
Andromeda pfaffiana Heer
Andromeda snowii Lesquereux
Aralia wellingtoniana Lesquereux
Aralia wellingtoniana vaughanii Knowlton
Benzoin venustum (Lesquereux) Knowlton
Brachyphyllum macrocarpum formosum Berry
Cinnamomum heerii Lesquereux
Cinnamomum membranaceum (Lesquereux) Hollick
Colutea primordialis Heer
Cornophyllum vetustum Newberry
Diospyros primæva Heer
Diospyros steenstrupi Heer
Eucalyptus geinitzi (Heer) Heer
Eugenia primæva Lesquereux
Ficus daphnogenoides (Heer) Berry
Ficus glascœana Lesquereux?
Inga cretacca Lesquereux
Laurophyllum minus Newberry
Laurus plutonia Heer
Laurus proteæfolia Lesquereux
Lirodendron pinnatifidum Lesquereux ?
Lirodendron quercifolium Newberry
Magnolia boulayana Lesquereux
Magnolia speciosa Heer
Malapoenna falcifolia (Lesquereux) Knowlton
Myrica emarginata Heer
Myrica longa (Heer) Heer
Oreodaphne alabamensis Berry
Palæocassia laurinea Lesquereux
Phyllites rhomboideus Lesquereux
Platanus primæva Lesquereux
Podozamites lanceolatus (L. and H.) Braun
Populus harkeriana Lesquereux
Rhamnus tenax Lesquereux
Rhus redditiformis Berry

[1] Berry, E. W., Bull. Torrey Bot. Club, vol. xxxix, 1912, pp. 387-406, pls. xxx-xxxii.

Salix deleta Lesquereux
Sapindus morrisoni Heer
Sterculia lugubris Lesquereux?
Tricalycites papyraceus Newberry
Viburnum robustum Lesquereux ?
Zizyphus lamarensis Berry

WESTERN NORTH AMERICA

THE WESTERN UNITED STATES

The Western Interior, so-called, embraces the vast area included in the Great Plains and Rocky Mountain provinces. The plant-bearing records extend from the base to the top of the Upper Cretaceous and are scattered over an area extending from southern Kansas to the Arctic Ocean. Much of this region, especially toward the north, is very insufficiently known. The records of fossil plants are based on the pioneer work of Lesquereux, Newberry, and Dawson, that of the last being particularly untrustworthy. In recent years Knowlton has made some admirable contributions to the knowledge of the floras of the Montana group and this author has also spent much time on a study of the floras of the Laramie, but this latter work is, for the most part, unpublished.

The Washita Series

The oldest plant-bearing beds of Upper Cretaceous age in this area are those known as the Cheyenne sandstone of southwestern Kansas. These form a part of the Washita division of the Comanche series of Hill,[1] and are usually referred to the top of the Lower Cretaceous by American geologists, although foreign paleontologists long ago indicated their Cenomanian age. A large flora was collected from these beds by Ward and Gould as long ago as 1897 and is now preserved in the U. S. National Museum. This flora has never been studied and so cannot be enumerated in the present connection, but both Knowlton and the writer have examined it and are in agreement as to its age. This section was described and the earlier literature was cited by Gould[2] in 1898. It

[1] Hill, R. T., 21st Ann. Rept. U. S. Geol. Survey, pt. vii, 1901, pp. 240-292.

[2] Gould, C. N., On a series of transition beds from the Comanche to the Dakota in southwestern Kansas. Amer. Jour. Sci. (iv), vol. v, 1898, pp. 169-175.

derives its importance from the fact that the Cheyenne sandstone is overlain by the marine Kiowa shales containing a Washita fauna, thus invalidating the proposal of the term Comanchean as a substitute for Lower Cretaceous.

Overlying the Kiowa shales are a series of intercalated sandstones and clays, the latter sometimes carrying leaves and the whole from 135 feet to 445 feet in thickness. Then comes the typical leaf-bearing Dakota sandstone which represents the littoral deposits of the advancing Benton sea and which forms a widespread deposit extending from northeastern Texas (Woodbine formation) northward to Minnesota and westward beyond the present site of the Rocky Mountains. It is represented in the Canadian provinces by the Mill Creek series of Dawson.

The Dakota Sandstone

The flora of the Dakota sandstone was first studied by Heer and the literature is too extensive for citation here. The chief contributions were made by Lesquereux, and little has been added since his final monograph was published in 1892.[1] North of the International Boundary the Dakota group flora was recognized by Dawson in the Mill Creek series of Canada.

Combining all of the published work dealing with areas within the United States, that for the Dominion of Canada being given in another place, results in the following lists of species:

Abietites ernestinæ Lesquereux
Acerites multiformis Lesquereux
Acerites pristinus Newberry
Alnites crassus Lesquereux
Alnites grandifolia Newberry
Ampelophyllum attenuatum Lesquereux
Ampelophyllum firmum Lesquereux
Ampelophyllum ovatum Lesquereux
Andromeda acuminata Lesquereux
Andromeda cretacea Lesquereux
Andromeda parlatorii Heer

[1] Lesquereux, L., The Flora of the Dakota Group. Mon. U. S. Geol. Survey, vol. xvii, 1891.

Andromeda parlatorii longifolia Lesquereux
Andromeda pfaffiana Heer
Andromeda snowii Lesquereux
Andromeda tenuinervis Lesquereux
Andromeda wardiana Lesquereux
Anisophyllum semialatum Lesquereux
Anona cretacea Lesquereux
Apeibopsis cyclophylla Lesquereux
Apocynophyllum sordidum Lesquereux
Aralia berberudufolia Lesquereux
Aralia concreta Lesquereux
Aralia formosa Heer
Aralia groenlandica Heer
Aralia masoni Lesquereux
Aralia quinquepartita Lesquereux
Aralia radiata Lesquereux
Aralia saportana Lesquereux
Aralia saportana deformata Lesquereux
Aralia subemarginata Lesquereux
Aralia tenuinervis Lesquereux
Aralia towneri Lesquereux
Aralia wellingtoniana Lesquereux
Araliopsoides cretacea (Newberry) Berry
Araliopsoides cretacea dentata (Lesquereux) Berry
Araliopsoides cretacea salisburiæfolia (Lesquereux) Berry
Araucaria spathulata Newberry
Arisæma cretacea Lesquereux
Aristolochites dentata Heer
Artocarpidium cretaceum Ettingshausen
Aspidiophyllum dentatum Lesquereux
Aspidiophyllum platanifolium Lesquereux
Aspidiophyllum trilobatum Lesquereux
Asplenium dicksonianum Lesquereux
Benzoin masoni (Lesquereux) Knowlton
Benzoin venustum (Lesquereux) Knowlton
Betula beatriciana Lesquereux
Betulites, stipules of, Lesquereux
Betulites crassus Lesquereux
Betulites cuneatus Lesquereux
Betulites denticulata Heer
Betulites grewiopsideus Lesquereux
Betulites inæquilateralis Lesquereux
Betulites lanceolatus Lesquereux
Betulites latifolius Lesquereux
Betulites multinervis Lesquereux
Betulites oblongus Lesquereux
Betulites obtusus Lesquereux

Betulites populifolius Lesquereux
Betulites populoides Lesquereux
Betulites quadratifolius Lesquereux
Betulites reniformis Lesquereux
Betulites rhomboidalis Lesquereux
Betulites rotundatus Lesquereux
Betulites rugosus Lesquereux
Betulites snowii Lesquereux
Betulites subintegrifolius Lesquereux
Betulites westii Lesquereux
Brachyphyllum macrocarpum Newberry
Bromelia ? rhomboidea Lesquereux
Bromelia ? tenuifolia Lesquereux
Callistemophyllum heerii Ettingshausen
Calycites sp. Lesquereux
Carpites coniger Lesquereux
Carpites cordiformis Lesquereux
Carpites liriophylii ? Lesquereux
Carpites tiliaceus (Heer) Lesquereux
Carpites ? sp. Lesquereux
Cassia polita Lesquereux
Cassia problematica Lesquereux
Caudex spinosus Lesquereux
Celastrophyllum crassipes Lesquereux
Celastrophyllum cretaceum Lesquereux
Celastrophyllum decurrens Lesquereux
Celastrophyllum ensifolium Lesquereux
Celastrophyllum myrsinoides Lesquereux
Celastrophyllum obliquum Lesquereux
Cinnamomum ellipsoideum Saporta and Mar
Cinnamomum heerii Lesquereux
Cinnamomum marioni Lesquereux
Cinnamomum membranaceum (Lesquereux) Hollick
Cinnamomum newberryi Berry
Cinnamomum scheuchzeri Heer
Cissites acerifolius Lesquereux
Cissites acuminatus Lesquereux
Cissites acutiloba Hollick
Cissites affinis Lesquereux
Cissites alatus Lesquereux
Cissites brownii Lesquereux
Cissites dentato-lobatus Lesquereux
Cissites formosus Heer
Cissites harkerianus Lesquereux
Cissites heerii Lesquereux
Cissites ingens Lesquereux
Cissites ingens parvifolia Lesquereux

Cissites insignis Heer
Cissites obtusilobus Lesquereux
Cissites platanoidea Hollick
Cissites populoides Lesquereux
Cissus browniana Lesquereux
Citrophyllum aligerum (Lesquereux) Berry
Colutea primordialis Heer
Cornus platyphylloides Lesquereux
Cornus præcox Lesquereux
Cratægus aceroides Lesquereux
Cratægus atavina Heer
Cratægus lacoei Lesquereux
Cratægus lawrenciana Lesquereux
Cratægus tenuinervis Lesquereux
Credneria ? microphylla Lesquereux
Cyatheites ? nebraskana (Heer) Knowlton
Cycadeospermum columnare Lesquereux
Cycadeospermum lineatum Lesquereux
Cycadites pungens Lesquereux
Dammarites caudatus Lesquereux
Dammarites emarginatus Lesquereux
Daphnophyllum angustifolium Lesquereux
Daphnophyllum dakotense Lesquereux
Dewalquea dakotensis Lesquereux
Dewalquea primordialis Lesquereux
Dioscorea ? cretacea Lesquereux
Diospyros ambiqua Lesquereux
Diospyros apiculata Lesquereux
Diospyros ? celastroides Lesquereux
Diospyros primæva Heer
Diospyros pseudoanceps Lesquereux
Diospyros rotundifolia Lesquereux
Diospyros steenstrupi ? Heer
Elæodendron speciosum Lesquereux
Encephalartos cretaceus Lesquereux
Eremophyllum fimbriatum Lesquereux
Eucalyptus dakotensis Lesquereux
Eucalyptus geinitzi Heer
Eucalyptus gouldii Ward
Eugenia primæva Lesquereux
Fagus cretacea Newberry
Fagus orbiculata Lesquereux
Fagus polycladus Lesquereux
Ficus ? angustata Lesquereux
Ficus austiniana Lesquereux
Ficus beckwithii Lesquereux
Ficus crassipes Heer

Ficus daphnogenoides (Heer) Berry
Ficus deflexa Lesquereux
Ficus distorta Lesquereux
Ficus glascœana Lesquereux
Ficus ? halliana Lesquereux
Ficus inæqualis Lesquereux
Ficus krausiana Heer
Ficus lanceolato-acuminata Ettingshausen
Ficus lesquereuxii (Lesquereux) Knowlton
Ficus macrophylla Lesquereux
Ficus magnoliæfolia Lesquereux
Ficus melanophylla Lesquereux
Ficus mudgei Lesquereux
Ficus præcursor Lesquereux
Ficus primordialis Heer
Ficus proteoides Lesquereux
Ficus reticulata (Lesquereux) Knowlton
Ficus sternbergii Lesquereux
Ficus ? undulata Lesquereux
Flabellaria ? minima Lesquereux
Galla quercina Lesquereux
Geinitzia sp.
Gleichenia kurriana Heer
Gleichenia nordenskioldi ? Heer
Grewiopsis æquidentata Lesquereux
Grewiopsis flabellata (Lesquereux) Knowlton
Grewiopsis mudgei Lesquereux
Hamamelites ? cordatus Lesquereux
Hamamelites quadrangularis Lesquereux
Hamamelites quercifolius Lesquereux
Hamamelites tenuinervis Lesquereux
Hedera cretacea Lesquereux
Hedera decurrens Lesquereux
Hedera microphylla Lesquereux
Hedera orbiculata (Heer) Lesquereux
Hedera ovalis Lesquereux
Hedera platanoidea Lesquereux
Hedera schimperi Lesquereux
Hymenæa dakotana Lesquereux
Hymenophyllum cretaceus Lesquereux
Ilex armata Lesquereux
Ilex borealis Heer
Ilex dakotensis Lesquereux
Ilex masoni Lesquereux
Ilex papillosa Lesquereux
Ilex scudderi Lesquereux
Ilex strangulata Lesquereux

Inga cretacea Lesquereux
Inolepis ? sp. Lesquereux
Juglandites ellsworthianus Lesquereux
Juglandites lacoei Lesquereux
Juglandites primordialis Lesquereux
Juglandites sinuatus Lesquereux
Juglans arctica Heer
Juglans crassipes Heer
Juglans debeyana (Heer) Lesquereux
Laurelia primæva Lesquereux
Laurus antecedens Lesquereux
Laurus atanensis Berry
Laurus hollæ Heer
Laurus knowltoni Lesquereux
Laurus lesquereuxii Berry
Laurus macrocarpa Lesquereux
Laurus microcarpa Lesquereux
Laurus modesta Lesquereux
Laurus nebrascensis Lesquereux
Laurus plutonia Heer
Laurus teliformis Lesquereux
Leguminosites constrictus Lesquereux
Leguminosites convolutus Lesquereux
Leguminosites coronilloides ? Heer
Leguminosites cultriformis Lesquereux
Leguminosites dakotensis Lesquereux
Leguminosites hymenophyllus Lesquereux
Leguminosites insularis Heer
Leguminosites omphalobioides Lesquereux
Leguminosites phaseolites ? Heer
Leguminosites podogonialis Lesquereux
Leguminosites truncatus Knowlton
Leguminosites sp. Lesquereux
Liquidambar integrifolius Lesquereux
Liriodendron acuminatum Lesquereux
Liriodendron acuminatum bilobatum Lesquereux
Liriodendron giganteum Lesquereux
Liriodendron giganteum cruciforme Lesquereux
Liriodendron intermedium Lesquereux
Liriodendron meekii Heer
Liriodendron pinnatifidum Lesquereux
Liriodendron primævum Newberry
Liriodendron semialatum Lesquereux
Liriodendron snowii Lesquereux
Liriodendron wellingtonii Lesquereux
Liriophyllum beckwithii Lesquereux
Liriophyllum obcordatum Lesquereux

Liriophyllum populoides Lesquereux
Lomatia ? saportanea Lesquereux
Lomatia ? saportanea longifolia Lesquereux
Lygodium trichomanoides Lesquereux
Macclintockia cretacea Heer
Magnolia alternans Heer
Magnolia amplifolia Heer
Magnolia boulayana Lesquereux
Magnolia capellinii Heer
Magnolia lacoeana Lesquereux
Magnolia obovata Newberry
Magnolia obtusata Heer
Magnolia pseudoacuminata Lesquereux
Magnolia speciosa Heer
Magnolia tenuifolia Lesquereux
Magnolia sp. Lesquereux
Malapoenna cretacea (Lesquereux) Knowlton
Malapoenna falcifolia (Lesquereux) Knowlton
Menispermites acutilobus Lesquereux
Menispermites cyclophyllus Lesquereux
Menispermites grandis Lesquereux
Menispermites menispermifolius (Lesquereux) Knowlton
Menispermites obtusiloba Lesquereux
Menispermites ovalis Lesquereux
Menispermites populifolius Lesquereux
Menispermites rugosus Lesquereux
Menispermites salinæ (Lesquereux) Knowlton
Myrica aspera Lesquereux
Myrica dakotensis Lesquereux
Myrica emarginata Heer
Myrica longa (Heer) Lesquereux
Myrica obliqua Knowlton
Myrica obtusa Lesquereux
Myrica schimperi Lesquereux
Myrica ? semina Lesquereux
Myrica sternbergii Lesquereux
Myrica ? trifoliata Newberry
Myrsine crassa Lesquereux
Myrsine gaudinii (Lesquereux) Berry
Myrtophyllum warderi Lesquereux
Negundoides acutifolia Lesquereux
Nordenskioldia borealis Heer
Nyssa snowiana Lesquereux
Nyssa vetusta Newberry
Oreodaphne cretacea Lesquereux
Palæocassia laurinea Lesquereux
Paliurus anceps Lesquereux

Paliurus cretaceus Lesquereux
Paliurus obovatus Lesquereux
Paliurus ovalis Dawson
Parrotia canfieldi Lesquereux
Parrotia grandidentata Lesquereux
Parrotia ? winchelli Lesquereux
Persea hayana Lesquereux
Persea leconteana Lesquereux
Persea schimperi Lesquereux
Persea sternbergii Lesquereux
Persoonia lesquereuxii Knowlton
Phaseolites formus Lesquereux
Phragmites cretaceus Lesquereux
Phyllites amissus Lesquereux
Phyllites amorphus Lesquereux
Phyllites aristolochiæformis Lesquereux
Phyllites betulæfolius Lesquereux
Phyllites celatus Lesquereux
Phyllites durescens Lesquereux
Phyllites erosus Lesquereux
Phyllites ilicifolius Lesquereux
Phyllites innecteus Lesquereux
Phyllites lacœi Lesquereux
Phyllites laurencianus Lesquereux
Phyllites obtusi-lobatus Heer
Phyllites perplexus Lesquereux
Phyllites rhoifolius Lesquereux
Phyllites rhomboidaleus Lesquereux
Phyllites snowii Lesquereux
Phyllites stipulæformis Lesquereux
Phyllites umbonatus Lesquereux
Phyllites vanonæ Heer
Phyllites zamiæformis Lesquereux
Phyllites sp. Lesquereux
Pinus quenstedti Heer
Pinus sp. Lesquereux
Platanus cissoides Lesquereux
Platanus diminutiva Lesquereux
Platanus heerii Lesquereux
Platanus latiloba Newberry
Platanus latior (Lesquereux) Knowlton
Platanus latior grandidentata (Lesquereux) Knowlton
Platanus latior subintegrifolia (Lesquereux) Knowlton
Podozamites angustifolius (Eichwald) Schimper
Podozamites haydenii Lesquereux
Podozamites lanceolatus (L. & H.) F. Braun

Podozamites oblongus Lesquereux
Podozamites stenopus Lesquereux
Populites cyclophylla (Heer) Lesquereux
Populites elegans Lesquereux
Populites lancastriensis Lesquereux
Populites litigiosus (Heer) Lesquereux
Populites microphyllus Lesquereux
Populites sternbergii Lesquereux
Populites winchelli Lesquereux
Populus aristolochioides Lesquereux
Populus berggreni Heer
Populus cordifolia Newberry
Populus elliptica Newberry
Populus harkeriana Lesquereux
Populus hyperborea Heer
Populus kansaseana Lesquereux
Populus leuce (Rossmassler) Unger
Populus microphylla Newberry
Populus stygia Heer
Proteoides acuta Heere
Proteoides grevilleæformis Heer
Proteoides lancifolius Heer
Protophyllocladus subintegrifolius (Lesquereux) Berry
Protophyllum crassum Lesquereux
Protophyllum credneroides Lesquereux
Protophyllum crenatum Knowlton
Protophyllum denticulatum Lesquereux
Protophyllum dimorphum Lesquereux
Protophyllum haydenii Lesquereux
Protophyllum integerrimum Lesquereux
Protophyllum leconteanum Lesquereux
Protophyllum minus Lesquereux
Protophyllum ? mudgei Lesquereux
Protophyllum multinerve Lesquereux
Protophyllum nebrascense Lesquereux
Protophyllum præstans Lesquereux
Protophyllum pseudospermoides Lesquereux
Protophyllum pterospermifolium Lesquereux
Protophyllum quadratum Lesquereux
Protophyllum querciforme Hollick
Protophyllum rugosum Lesquereux
Protophyllum sternbergii Lesquereux
Protophyllum ? trilobatum Lesquereux
Protophyllum undulatum Lesquereux
Prunus (Amygdalus) antecedens Lesquereux
Prunus cretacea Lesquereux
Ptenostrobus nebrascensis Lesquereux

Pteris dakotensis Lesquereux
Pterospermites longeacuminatus Lesquereux
Pterospermites modestus Lesquereux
Pyrus cretacea Newberry
Quercus alnoides Lesquereux
Quercus antiqua Newberry
Quercus cuneata Newberry
Quercus dakotensis Lesquereux
Quercus ? ellsworthianus Lesquereux
Quercus glascœna Lesquereux
Quercus hexagona Lesquereux
Quercus hieracifolia (Debey) Hosius
Quercus holmesii Lesquereux?
Quercus hosiana Lesquereux
Quercus kanseana (Lesquereux) Knowlton
Quercus latifolia Lesquereux
Quercus morrisoniana Lesquereux
Quercus poranoides Lesquereux
Quercus rhamnoides Lesquereux
Quercus salicifolia Newberry
Quercus sinuata Newberry
Quercus spurio-ilex Knowlton
Quercus suspecta Lesquereux
Quercus wardiana Lesquereux
Rhamnites apiculatus Lesquereux
Rhamnus inæquilateralis Lesquereux
Rhamnus mudgei Lesquereux
Rhamnus prunifolius Lesquereux
Rhamnus revoluta Lesquereux
Rhamnus similis Lesquereux
Rhamnus tenax Lesquereux
Rhus powelliana Lesquereux
Rhus uddeni Lesquereux
Rhus ? westii Knowlton
Salix cuneata Newberry
Salix deleta Lesquereux
Salix flexuosa Newberry
Salix hayei Lesquereux
Salix lesquereuxii Berry
Salix meekii Newberry
Salix nervillosa Heer
Salix sp. (catkins) Lesquereux
Sapindus diversifolius Lesquereux
Sapindus morrisoni Heer
Sapotacites haydenii Heer
Sapotacites sp ? Lesquereux
Sassafras acutilobum Lesquereux

Sassafras acutilobum grossedentatum Lesquereux
Sassafras dissectum Lesquereux
Sassafras dissectum symmetricum Hollick
Sassafras mirabile Lesquereux
Sassafras mudgei Lesquereux
Sassafras papillosum Lesquereux
Sassafras platanoides Lesquereux
Sassafras primordiale Lesquereux
Sassafras subintegrifolium Lesquereux
Scerotites sp. (Lesquereux) Knowlton
Sequoia condita Lesquereux
Sequoia fastigiata (Sternberg) Heer
Sequoia formosa Lesquereux
Sequoia gracillima (Lesquereux) Newberry
Sequoia reichenbachi (Geinitz) Heer
Sequoia winchelli Lesquereux
Smilax grandifolia cretacea Lesquereux
Smilax undulata Lesquereux
Sphærites problematicus Knowlton
Sphenopteris corrugata Newberry
Sterculia aperta Lesquereux
Sterculia leneariloba Lesquereux
Sterculia lugubris Lesquereux
Sterculia mucronata Lesquereux
Sterculia reticulata Lesquereux
Sterculia snowii Lesquereux
Sterculia snowii disjuncta Lesquereux
Sterculia tripartita (Lesquereux) Knowlton
Torreya oblanceolata Lesquereux
Viburnites crassus Lesquereux
Viburnites evansanus Ward
Viburnites masonii Lesquereux
Viburnum ellsworthianum Lesquereux
Viburnum grewiopsidium Lesquereux
Viburnum lesquereuxi Ward
Viburnum lesquereuxi commune Lesquereux
Viburnum lesquereuxi cordifolium Lesquereux
Viburnum lesquereuxi lanceolatum Lesquereux
Viburnum lesquereuxi latius Lesquereux
Viburnum lesquereuxi longifolium Lesquereux
Viburnum lesquereuxi rotundifolium Lesquereux
Viburnum lesquereuxi ? tenuifolium Lesquereux
Viburnum robustum Lesquereux
Viburnum sphenophyllum Knowlton
Williamsonia elocata Lesquereux
Zamites sp. Lesquereux
Zizyphus dakotensis Lesquereux
Zonarites digitatus (Brongniart) Geinitz

The Colorado Group[1]

The Dakota sandstone is overlain by the Benton shale and this in turn throughout a part of its area by the Niobrara limestone, both marine deposits carrying abundant faunas but no land plants. Together they consitute the Colorado group of the classic section of Meek and Hayden, and they are more or less loosely correlated with the Turonian and Emscherian stages of the European section. On the boundary between the Colorado and Montana groups, or perhaps representing a part of the westward littoral phase of the Niobrara chalk of the more easterly part of the Interior basin is the Eagle sandstone from which the following plants have been described:[2]

Ficus missouriensis Knowlton
Juglans ? missouriensis Knowlton
Laurus ? sp.
Liriodendron alatum Newberry
Platanus wardii Knowlton
Protophyllocladus polymorphus (Lesquereux) Berry
Quercus ? montanensis Knowlton

The Montana Group[1]

Overlying the Eagle formation in the western part of the Interior basin the following series of formations have been differentiated, *i. e.*, Claggett, Belly River or Judith River, and Bearpaw. These are represented to the eastward by the Pierre formation. Overlying this is the Fox Hills sandstone which is the topmost member of the Montana group. Both this and all other Upper Cretaceous horizons in the province in accordance with the official practice of the U. S. Geological Survey have received local formation names too numerous to be considered in the present brief review. The reader who desires to pursue this subject in detail is referred to the excellent summary contained in the explanatory text for the geological map of North America,[3] where the literature is fully cited. The

[1] There is no geologic or paleontologic basis for the term Colorado group or Montana group.

[2] List furnished by F. H. Knowlton of the U. S. National Museum.

[3] Index to the stratigraphy of North America. Prof. Paper U. S. Geol. Survey No. 71, 1912.

following list of plants from the Montana group has kindly been furnished by Dr. F. H. Knowlton:

Anemia elongata (Newberry) Knowlton
Asimina eocenica Lesquereux ?
Asplenium tenellum Knowlton
Asplenium wyomingense Knowlton
Asplenium sp.
Betulites ? hatcheri Knowlton
Brachyphyllum macrocarpum Newberry
Carpites alatus Knowlton
Carpites judithæ Knowlton
Carpites pruni Knowlton
Carpites triangulosus Lesquereux
Castalia duttoniana Knowlton
Castalia stantoni Knowlton
Cinnamomum affine Lesquereux ?
Cornus studeri Heer ?
Cunninghamites elegans (Corda) Endlicher
Cunninghamites pulchellus Knowlton
Cunninghamites recurvatus Hosius and von der Marck ?
Dammara acicularis Knowlton
Diospyros cf. *brachysepala* Al. Braun
Diospyros judithæ Knowlton
Dryophyllum crenatum Lesquereux
Dryophyllum falcatum Ward
Dryophyllum subfalcatum Lesquereux
Dryopteris lloydii Knowlton
Ficus asarifolia Ettingshausen
Ficus dalmatica Ettingshausen
Ficus hesperia Knowlton
Ficus incompleta Knowlton
Ficus irregularis Lesquereux
Ficus montana Knowlton
Ficus multinervis Heer
Ficus planicostata Lesquereux ?
Ficus populoides Knowlton
Ficus problematica Knowlton
Ficus rhamnoides Knowlton
Ficus spinosissima Ward
Ficus squarrosa Knowlton
Ficus trinervis Knowlton
Ficus wardii Knowlton
Fucus lignatum Lesquereux
Geinitzia biformis (Lesquereux) Knowlton
Geinitzia formosa Heer
Ginkgo laramiensis Ward

Grewiopsis cleburni Lesquereux
Halymenites major Lesquereux
Laurus præstans Lesquereux
Laurus cf. *primigenia* Unger
Liriodendron laramiense Ward
Lycopodium lesquereuxiana Knowlton
Magnolia pulchra Ward
Marsilia ? attenuata (Lesquereux) Hollick
Malapoenna macrophylloides Knowlton
Menispermites knightii Knowlton
Myrica torreyi Lesquereux
Nelumbo intermedia Knowlton
Osmunda montanensis Knowlton
Ottelia americana Lesquereux
Phyllites denticulatus Knowlton
Phyllites intricata Knowlton
Phyllites triloba Knowlton
Pinus quenstedti Heer
Pistia corrugata Lesquereux
Podogonium americanum Lesquereux
Populites amplus Knowlton
Populus cretacea Knowlton
Populus melanarioides Lesquereux
Populus mutabilis ovalis Heer ?
Populus obovata Knowlton
Populus wardii Knowlton
Pterospermites undulatus Knowlton
Pterospermites wardii Knowlton
Quercus dentonoides Knowlton
Quercus judithæ Knowlton
Quercus lesquereuxiana Knowlton
Quercus montana Knowlton
Rhamnus salicifolius Lesquereux
Rhus membranacea Lesquereux
Salix angusta Al. Brun
Salix stantoni Knowlton
Salix sp.
Sapindus inexpactans Knowlton
Sabal sp. nov.
Selaginella falcata Lesquereux
Selaginella laciniata Lesquereux
Sequoia heterophylla Velenovsky
Sequoia longifolia Lesquereux
Sequoia reichenbachi (Geinitz) Heer
Thuya cretacea (Heer) Newberry?
Trapa cuneata Knowlton
Trapa microphylla Lesquereux
Viburnum anomalum Knowlton

Viburnum hollickii Berry
Viburnum montanum Knowlton
Viburnum problematicum Knowlton
Widdringtonites complanata Lesquereux
Woodwardia crenata Knowlton
Woodwardia sp.

The Laramie Formation

In those parts of the region where the Upper Cretaceous section is complete it ends with the Laramie formation. The age of this and similar coal-bearing beds has been the subject of controversy since the days of King and Hayden, and a vast literature has been inspired, the question still being a very live issue among geologists and paleontologists. By definition the Laramie was the topmost member of the conformably Cretaceous series and the Federal Survey has recently promulgated the ruling that the lithologically somewhat similar but unconformably overlying beds (Lance, Hell Creek, Ceratops, Raton, Arapahoe, Denver, etc.) are to be considered as of early Eocene age.

It is almost impossible to disentangle the flora of the true Laramie in published works, and I am again indebted to Dr. F. H. Knowlton, who is completing a monograph of this flora at the present time, for the following list of the Laramie plants from this horizon in the Denver basin and adjacent areas in Colorado where the stratigraphic relations are well understood. Many additional and new forms will be described in Dr. Knowlton's contemplated monograph.

Anemia supercretacea Hollick
Anemia sp.
Anona robusta Lesquereux
Anona sp. nov.
Apocynophyllum sp. nov.
Aristolochia sp. nov.
Artocarpus lessigiana (Lesquereux) Knowlton
Artocarpus sp. nov.
Asplenium sp. nov.
Carpites rhomboidalis Lesquereux
Carpites sp. nov.
Ceanothus sp. nov.
Celastrus sp. nov.
Cercis eocenica Lesquereux
Cinnamomum affine Lesquereux

Cornus suborbifera Lesquereux
Cornus sp. nov.
Cyperacites sp. nov.
Cycadeoidea mirabilis (Lesquereux) Ward
Dammara sp.
Delesseria fulva Lesquereux
Dombeyopsis obtusa Lesquereux
Dombeyopsis trivialis Lesquereux
Dombeyopsis sp. nov.
Dryopteris intermedia (Lesquereux) Knowlton
Dryopteris polypodioides (Ettingshausen) Knowlton
Dryopteris sp. nov.
Equisetum prælævigatum Cockerell
Eriocaulon ? porosum Lesquereux
Ficus arenacea Lesquereux
Ficus crossii Ward
Ficus dalmatica Ettingshausen
Ficus denveriana Cockerell ?
Ficus irregularis (Lesquereux) Knowlton
Ficus latifolia (Lesquereux) Knowlton
Ficus multinervis Heer
Ficus bavicularis Cockerell
Ficus planicostata Lesquereux
Ficus smithsoniana Lesquereux
Ficus sp. nov. (nine)
Geinitzia longifolia (Lesquereux) Knowlton
Gymnogramme gardneri Lesquereux
Hedera sp. nov.
Hicoria sp. nov.
Ilex. sp. nov.
Juglans leconttana Lesquereux
Juglans sp. nov. (four)
Laurus wardiana Knowlton
Laurus sp. nov.
Leguminosites sp. nov. (two)
Lygodium compactum Lesquereux
Magnolia sp. nov. (two)
Malapoenna sp. nov.
Mimosites sp. nov.
Myrica torreyi Lesquereux
Myrica torreyi minor Lesquereux
Myrica sp. nov. (two)
Negundo sp. nov.
Nelumbo tenuifolia (Lesquereux) Knowlton
Onoclea fecunda (Lesquereux) Knowlton
Paliurus zizyphoides Lesquereux
Phragmites sp.
Phyllites sp. nov. (four)

Pistacia sp. nov. (two)
Platanus platanoides (Lesquereux) Knowlton
Populus sp. nov.
Pteris sp. nov.
Quercus sp. nov.
Rhamnus discolor Lesquereux
Rhamnus elegans Newberry
Rhamnus goldianus Lesquereux ?
Rhamnus salicifolius Lesquereux ?
Rhamnus sp. nov. (three)
Sabal sp. nov.
Salix integra Gœppert
Salix sp. nov.
Sequoia acuminata Lesquereux
Sequoia reichenbachi (Geinitz) Heer
Smilax sp. nov.
Zizyphus sp. nov. (four)

The Vermejo Formation

An extensive flora from the Cretaceous section in northeastern New Mexico and southeastern Colorado, there known as the Vermejo formation, has been described by Dr. Knowlton in manuscript. From this report now in press I am permitted to reproduce the following list of fossil plants:

Abietites dubius Lesquereux
Acrostichum haddeni Hollick
Amelanchier sp. nov.
Anemia robusta Hollick
Anemia supercretacea Hollick
Artocarpus sp. nov.
Asplenium sp. nov.
Brachyphyllum cf. *macricarpum* Newberry
Canna sp. nov.
Caulerpites incrassatus Lesquereux
Celastrus sp. nov. (two)
Chondrites bulbosus Lesquereux
Chondrites subsimplex Lesquereux
Cissites sp. nov.
Colutea sp. nov.
Credneria sp. nov.
Cupressinoxylon sp. nov. (two)
Diospyros sp. nov.
Ficus dalmatica Ettingshausen
Ficus rhamnoides Knowlton
Ficus spinosissima Ward

Ficus wardii Knowlton
Ficus sp. nov. (twelve)
Geinitzia formosa Heer
Gleichenia delicatula Heer ?
Gleichenia rhombifolia Hollick
Halymenites major Lesquereux
Halymenites striatus Lesquereux
Hedera sp. nov.
Juglans sp. nov. (two)
Laurus sp. nov.
Liriodendron alatum Newberry
Myrica torreyi Lesquereux
Myrica sp. nov.
Osmunda sp. nov.
Phyllites sp. nov. (eleven)
Platanus sp.
Populus sp. nov.
Polystichum hillsianum Hollick
Pteris erosa Lesquereux
Pteris russellii Newberry
Pterospermites wardii Knowlton
Pterospermites sp. nov. (two)
Quercus sp. nov (two).
Rhamnus salicifolius Lesquereux
Rosellenites lapidum (Lesquereux) Knowlton
Sabal sp. nov.
Salix sp. nov. (two).
Sequoia reichenbachi (Geinitz) Heer
Sequoia sp. nov.
Sparganium sp.
Sterculia sp. nov.
Taxodium ? sp.
Viburnum montanum Knowlton
Viburnum problematicum Knowlton
Viburnum sp.
Vitis sp. nov.
Widdringtonia ? complanata Lesquereux
Woodwardia crenata Knowlton
Zizyphus sp. nov.

THE DOMINION OF CANADA

The plant-bearing beds of the Dominion all occur in the western provinces and they appear to be, for the most part, northward extensions of the better known Cretaceous horizons of the Western Interior and Pacific Coast regions of the United States. As might be expected in the vast and inaccessible region of the Northwest much of the area is unex-

plored and most of the work that has been done is of a reconnaissance nature. Among the chief contributors to the geology have been Richardson, Selwyn, Dawson, McConnell, and Tyrrell, and their work is briefly summarized in the recently published Index to the Stratigraphy of North America.[1] The chief contributor to the paleobotany was the late Sir William Dawson,[2] although minor contributions have been made by Heer,[3] Newberry,[4] Lesquerex,[5] and Penhallow.[6]

The oldest horizon where Upper Cretaceous plants have been found is in the so-called Mill Creek series which Dawson correlated with the Dakota sandstone of the United States. From these beds Dawson recorded the following forms:

Alnites insignis Dawson ?
Aralia rotundata Dawson
Aralia westoni Dawson
Aralia sp. Dawson
Asplenium albertum Dawson

[1] Prof. Paper U. S. Geol. Survey, No. 71, 1912, pp. 693-704.

[2] Dawson, J. W., Note on the fossil plants from British Columbia collected by Mr. James Richardson in 1872. Geol. Survey Can. Rept. of Prog. for 1872-72, Appendix 1, pp. 66-71, pl. i, 1873.

——— On the Cretaceous and Tertiary floras of British Columbia and the Northwest Territory. Trans. Roy. Soc. Canada, 1882, vol. i, sec. iv, 1883, pp. 15-34, pl. i-viii.

——— On the Mesozoic floras of the Rocky Mountain region of Canada. *Ibid.*, vol. iii, sec. iv, 1885, pp. 1-22, pl. i-iv, 1886.

——— Note on the fossil woods and other plant remains from the Cretaceous and Laramie formations of the Western Territories of Canada. *Ibid.*, vol. v, sec. iv, 1887, pp. 31-37, 1888.

——— On Cretaceous plants from Port McNeill, Vancouver Island. *Ibid.*, vol. vi, sec. iv, 1888, pp. 71, 72, 1889.

——— On the Correlation of early Cretaceous floras in Canada and the United States, and on some new plants of the period. *Ibid.*, vol. x, sec. iv, 1892, pp. 79-93, 1893.

——— On new species of Cretaceous plants from Vancouver Island. *Ibid.*, vol. xi, sec. iv, 1893, pp. 53-72, pl. v-xii, 1894.

[3] Heer, O., Neue Denks. schweiz. Gesell. gesammt. Naturwiss., vol. xxi, 1865, pp. 1-10, pl. i, ii.

[4] Newberry, J. S., Boston Jour. Nat. Hist., vol. vii, 1863, pp. 506-524.

[5] Lesquereux, L., Amer. Jour. Sci. (ii), vol. xxvii, 1859, pp. 360-363.

[6] Penhallow, D. P., Notes on Cretaceous and Tertiary Plants of Canada. Trans. Roy. Soc. Canada (II), vol. viii, sec. iv, 1902, pp. 31-91.

——— Report on a collection of fossil woods from the Cretaceous of Alberta. Ottawa Nat., vol. xxii, 1908, pp. 82-85, figs. 1-6.

Cinnamomum canadense Dawson
Cissites affinis Lesquereux
Cissites affinis ampla Dawson
Dicksonia munda Dawson
Ficus daphnogenoides (Heer) Berry
Gleichenia gracilis Heer
Gleichenia kurriana Heer
Hedera ovalis Lesquereux
Juglandites cretacea Dawson
Laurophyllum debile Dawson
Laurus crassinervis Dawson
Liquidambar integrifolius Lesquereux
Macclintockia cretacea Heer
Magnolia magnifica Dawson
Paliurus montanus Dawson
Paliurus ovalis Dawson
Platanus heerii Lesquereux
Protophyllum rugosum Dawson
Sterculia vetustula Dawson
Williamsonia recentior Dawson

From the Cretaceous of the northern part of Vancouver Island (Nanaimo, Port McNeill, Baynes Sound) and the probable extension of these beds on Protection and Newcastle islands Dawson recorded the following:

Adiantites prælongus Dawson
Alnites insignis Dawson
Anisophyllum sp. Dawson
Articarpophyllum occidentale Dawson
Betula perantiqua Dawson
Betula sp. Dawson
Carpolithes meridionalis Dawson
Carpolithes sp. Dawson
Ceanothus cretaceous Dawson
Cinnamomum heerii Lesquereux
Cinnamomum newberryi Berry
Cladophlebis columbiana Dawson
Cornus obesus Dawson
Dammarites dubius Dawson
Davallites richardsoni Dawson
Diospyros calyx Dawson
Diospyron eminens Dawson
Diospyros vancouverensis Dawson
Dryopteris kennerleyi (Newberry) Knowlton
Fagophyllum nervosum Dawson
Fagophyllum retosum Dawson

Ficus contorta Dawson
Ficus laurophyllidia Dawson
Ficus magnoliæfolia Lesquereux
Ficus rotundata Dawson
Ficus wellingtoniæ Dawson
Ficus sp. Dawson
Ginkgo baynesiana (Dawson) Knowlton
Ginkgo pusilla (Dawson) Knowlton [1]
Glyptostrobus sp.
Juglandites fallax Dawson
Juglandites ? sp.
Juglans harwoodensis Dawson
Laurophyllum insigne Dawson
Laurus colombi Heer
Liriodendron prætulipiferum Dawson
Liriodendron succedens Dawson
Macclintockia trinervis Heer
Macrotæniopteris vancouverensis Dawson
Magnolia capellinii Heer
Magnolia occidentalis Dawson
Menispermites sp.
Neuropteris castor Dawson
Nilsonia lata Dawson
Noeggerathiopsis robinsi Dawson
Paliurus neilii Dawson
Pecopteris sp.
Persea leconteana Lesquereux
Phragmites cordaiformis Dawson
Phyllites sp.
Populites probalsamifera Dawson
Populus longior Dawson
Populus protozadachii Dawson
Populus rectinervata Dawson
Populus rhomboidea Lesquereux
Populus trinervis Dawson
Populus sp.
Proteoides major Dawson
Proteoides neillii Dawson
Proteoides sp.
Protophyllum nanaimo Dawson
Protophyllum sp.
Pteris glossopteroides Dawson
Quercus holmesii Lesquereux
Quercus multinervis Lesquereux
Quercus ? occidentalis Dawson

[1] Antedated by Heer 1876.

Quercus platinervis Lesquereux
Quercus victoriæ Dawson
Quercus sp.
Sabal imperialis Dawson
Sabal pacifica Dawson
Salix sp.
Sassafras sp.
Sphenopteris elongata Newberry
Tæniopteris plumosa Dawson
Taxodium cuneatum Newberry
Taxodium sp.
Tumion densifolium (Dawson) Knowlton
Ulmophyllum priscum Dawson
Ulmus dubia Dawson

These beds probably represent the Chico horizon of the Pacific Coast of the United States.

From beds of possibly Colorado age on the Peace and Pine rivers Dawson recorded the following:

Antholithus horridus Dawson
Asplenium niobrara Dawson
Betula sp. Dawson
Cycadites unjiga Dawson
Diospyros nitida Dawson
Fagus prato-nucifera Dawson
Magnolia tenuifolia Lesquereux
Myrica longa (Heer) Lesquereux
Populites cyclophylla (Heer) Lesquereux
Protophyllum boreale Dawson
Protophyllum leconteanum Lesquereux
Tumion dicksonioides (Dawson) Knowlton

From beds classed as of Pierre age the same author recorded the following:

Abietites tyrrelli Dawson
Betula sp.
Hicoria sp.
Populus sp.
Sequoia sp.
Ulmus sp.

From the Belly River formation Dawson recorded the following:

Acer saskatchewanense Dawson
Betula sp.
Ginko sp.
Nelumbium saskatchewanense Dawson

Nelumbo dawsonii Hollick
Pistia corrugata Lesquereux
Pityoxylon sp.
Platanus ? sp.
Podocarpites tyrellii Dawson
Populus latidentata Dawson
Sequoia sp.
Taxites sp.
Thuja sp.
Trapa borealis Heer

In all of the foregoing lists taken from Dawson's numerous papers the determinations are frequently unreliable and illustrations, when present, often fail to do justice to the material.

SOUTH AMERICA

The only contribution to the Upper Cretaceous paleobotany of South America is a short unillustrated paper by Kurtz[1] published in 1902, and describing a small collection of leaves made by Hauthal at Cerro Guido in the province of Santa Cruz, Argentina.[2] The Swedish expedition to South America in 1907-1909 made collections of Upper Cretaceous plants in both Patagonia and Tierra-del-Fuego, but these have not yet been reported upon.[3]

The following species are recorded by Kurtz:

Abietites valentini Kurtz
Araucarites patagonica Kurtz
Asplenium dicksonianum Heer
Betulites sp.
Cinnamomum heerii Lesquereux
Cissites affinis Lesquereux
Gleichenites sp.
Liquidambar integrifolium Lesquereux
Liriodendron meekii Heer
Litsæa expansa Saporta
Menispermites obtusiloba Lesquereux
Oreodaphne heerii Gauden

[1] Kurtz, F., Contribuciones à la palæophytologia Argentina: Sobre la existencia de una Dakota Flora en la Patagonia austro-occidental, Revista Museo La Platà, vol. x (1899), 1902, pp. 43-60.

[2] See Berry, E. W., Science n. s., vol. xxiii, 1906, pp. 509, 510.

[3] Halle, T. G., Kgl. Svenska Vetens-Akad, Handl., Bd. 51, No. 3, p. 3, 1913.

Persea hayana Lesquereux
Persea schimperi Lesquereux
Persea sternbergii Lesquereux
Perseophyllum hauthalianum Kurtz
Platanus obtusiloba Lesquereux
Platanus primæva grandidentata Lesquereux
Populus acerifolia Newberry
Populus cf. *cicrophylla* Newberry
Populus cf. *nebrascensis* Newberry
Populites lancastriensis Lesquereux
Protophyllum cf. *rugosum* Lesquereux
Quercus primordialis Lesquereux
Salix lesquereuxii Berry
Sassafras acutilobum Lesquereux
Sassafras cretaceum Newberry
Sassafras mudgei Lesquereux
Sassafras mudgei var.
Sassafras subintegrifolium Lesquereux
Sequoia brevifolia Heer

The foregoing list comprises thirty-one forms including new species in *Abietites, Araucarites,* and *Perseophyllum.* Eliminating these there are twenty-eight forms, of which twenty-one, or seventy-five per cent, are characteristic types of the Dakota flora. It is a significant fact that the meager flora from the heretofore most southern known Dakota outcrop containing plants, namely, the Woodbine formation of Texas, contains two species that are identical with Argentinean forms. Four identical forms are found in the Magothy and three in the Raritan of the Atlantic Coastal Plain, two occur in the Atane beds of the west coast of Greenland and one occurs in the Patoot beds of the same region. Two forms are common to the Cenomanian of Bohemia and one is found in the Senoninan of Prussia and Bulgaria. Kurtz identifies one species with a basal Eocene form of North America and another with a basal Eocene species of Belgium. The remarkable similarity of this flora to that developed in the central West during the mid-Cretaceous certainly points very strongly to a community of origin. Were the evidence less convincing in its array of forms it would be an easy matter to infer that Kurtz's *Liriodendron meekii* was a leguminous leaflet, and that his species of *Cinnamomum, Litsæa* and *Sassafras* were simply the Upper Cretaceous precursors of the lauraceous forms which occur so abundantly in the modern flora of

tropical South America; but such a view is entirely untenable in the light of the disclosed species of *Liquidambar, Cissites, Persea, Menispermites, Platanus, Populus, Betulites, Quercus,* etc.

The Argentinean geologists regard these beds as Cenomanian, but they are probably not older than the Turonian.

ANTARCTICA

This vast continental area, so little known, has in recent years furnished traces of the Glossopteris flora,[1] an extensive late Jurassic flora,[2] a few Upper Cretaceous woods[3] and coniferous twigs,[2] and a series of Tertiary woods,[3] as well as an extensive series of leaf remains[4] of early Tertiary age.

The traces of a flora that is referred to the Upper Cretaceous are neither extensive nor important. They comprise coniferous twigs which Nathorst compared with *Sequoia fastigiata* (Sternberg) a characteristic Upper Cretaceous species of the northern hemispheres. Gothan described the following woods:

Phyllocladoxylon antarcticum Gothan
Dadoxylon pseudoparenchymatosum
Laurinoxylon uniseriatum
Nothofagoxylon scalariforme

but which of these are Cretaceous and which are Tertiary is not certainly known.

AUSTRALIA

There have been more worthless articles written about the Cretaceous and Tertiary floras of Australia than of any other equal area of the earth's surface. With the exception of Ettingshausen and Ferd. von

[1] Seward, A. C., British Antarctic (Terra Nova) Expedition, 1910, Geology, vol. i, No. 1, 1914, pp. 49, tf. 6, pls. viii, 2 maps.

[2] Halle, T. G., The Mesozoic Flora of Graham Land. Swedish South Polar Expedition, 1901-1903, vol. iii, 1913, pp. 123, pls. ix, tf. 19.

[3] Gothan, W., Die fossilen Hölzer von der Seymour-und Snow Hill Insel. *Ibid*, 1903, 34 pp. 2 pls.

[4] Dusen, P., Die tertiare Flora der Seymour Insel. *Ibid.*, 1908, 28 pp., 4 pls.

Müller, none of the contributors appears to have had any knowledge of botany or any acquaintance with paleobotany. The latter student did a small amount of admirable work on the fossil fruits of the late Tertiary gold drifts. The former did pioneer work on the floras of what he called Cretaceous and Eocene. Since his day the age determinations have been shifted back and forth. The Eocene floras are now considered Oligocene and Miocene. The Cretaceous flora he described may or may not be Cretaceous. Ettingshausen deducted certain broad conclusions from his studies, the most notable being that as late as the Tertiary the Australian flora was not a provincial flora but a part of the cosmopolitan flora. Doubtless many of Ettingshausen's determinations are oversanguine and his comparisons in general were with European fossil floras rather than with existing Australian floras, at the same time it should be pointed out that such a statement has a much greater theoretic probability when applied to the Cretaceous or Eocene than when applied to the later Tertiary.

The following were included by Ettingshausen[1] in the Cretaceous:

Acrostichum primordiale Ettingshausen
Andromeda australiensis Ettingshausen
Apocynophyllum warraghianum Ettingshausen
Aralia subformosa Ettingshausen
Artocarpidium pseudocretaceum Ettingshausen
Aulacolepis rhomboidalis Ettingshausen
Banisteriophyllum cretaceum Ettingshausen
Banksia crenata Ettingshausen
Banksia cretacea Ettingshausen
Banksia plagioneura Ettingshausen
Banksia sublongifolia Ettingshausen
Carpolithus complanatus Ettingshausen
Carpolithus fagiformis Ettingshausen
Carpolithus semisulcatus Ettinshausen
Carpolithus siliculæformis Ettingshausen
Cassia etheridgei Ettingshausen
Cassia præmemnonia Ettingshausen
Cassia præphaseolitoides Ettingshausen
Casuarina primæva Ettingshausen
Ceratopetalum primigenium Ettingshausen

[1] Ettingshausen, C. von, Beiträge zur Kenntniss der Kreideflora Australiens. Denks. k. Akad. Wiss. Wein, Bd. lxii, 1895, pp. 1-56, pl. i-iv.

Ceratophyllum australis Ettingshausen
Cinnamomum haastii Ettingshausen
Cinnamomum primigenium Ettingshausen
Conospermites linearifolius Ettingshausen
Cyperacites ambiguus Ettingshausen
Debeya affinis Ettingshausen
Debeya australiensis Ettingshausen
Diemenia lancifolia Ettingshausen
Diospyros cretacea Ettingshausen
Dryophyllum lesquereuxii Ettingshausen
Elæodendron priscum Ettingshausen
Etheridgea subglobosa Ettingshausen
Eucalyptus[1] *cretacea* Ettingshausen
Eucalyptus davidsoni Ettingshausen
Eucalyptus oxleyana Ettingshausen
Eucalyptus scoliophylla Ettingshausen
Eucalyptus warraghiana Ettingshausen
Fagus leptoneura Ettingshausen
Fagus præninnisiana Ettingshausen
Fagus præulmifolia Ettingshausen
Ficus ipswichiana Ettingshausen
Glyptostrobus australis Ettingshausen
Grevillea oxleyana Ettingshausen
Laurus plutonina Ettingshausen
Leguminosites pachyphyllum Ettingshausen
Malpighiastrum cretaceum Ettingshausen
Monimia prævestita Ettingshausen
Myrica pseudo-lignitum Ettingshausen
Myricophyllum longepetiolatum Ettingshausen
Myrtophyllum latifolium Ettingshausen
Palmæ sp. indet.
Phyllites actinoneuron Ettingshausen
Podalyriophyllum brochiodromum Ettingshausen
Proteoides australiensis Ettingshausen
Quercus[1] *colpophylla* Ettingshausen
Quercus eucalyptoides Ettingshausen
Quercus nelsonica Ettingshausen
Quercus pseudo-chlorophylla Ettingshausen
Quercus rosmarinifolia Ettingshausen
Quercus stokesii Ettingshausen
Quercus sp.
Rhopalophyllum australe Ettingshausen
Thuites wilkinsoni Ettingshausen
Zosterites angustifolius Ettingshausen

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[1] The identity of this and the following forms with *Eucalyptus* is questionable.

[2] This and the following are doubtfully allied to *Quercus*.

This list includes one fern, two gymnosperms, three monocotyledons, and fifty-six dicotyledons. The largest families are the *Fagaceæ* with ten species, the *Proteaceæ* with eight, the *Myrtaceæ* with six, and the *Leguminosæ* with five.

NEW ZEALAND

Through the instrumentality of Julius Haast, at one time chief assistant of Ferdinand von Hochstetter in the geologic work of the latter in the provinces of Auckland and Nelson (1859), and afterward director of the geological surveys of Canterbury and Westland, collections of fossil plants were submitted to Ettingshausen [1] and partially described by him in 1887. Plants from four localities were considered as Cretaceous, and thirty-seven species, all new, were described. These came from the so-called Cretaceo-Tertiary of Hector,[2] and the localities were Grey River in Westland, and Reefton, Pakawan and Waugapeka in Nelson, all in South Island. In the recently published Geology of New Zealand by Parks [3] the Reefton coals are referred to the Eocene Waimangaroa series and the Pakawan plants to the brown coal or Oamaru series which is considered to be of Miocene age. More recently Marshall [4] considers the Cretaceous to be altogether wanting, so that a final conclusion must await further study.

It appears that the late James Hector projected an account of the fossil flora of New Zealand,[5] publishing various lists of names (*nomina nuda*) and circulating a series of unnamed lithographic plates, some of his figures being reproduced in text-books, as for example, in Park's geology (*op. cit.*).

Ettingshausen referred the following to the Cretaceous but, as previously pointed out, some of these are Tertiary and very probably some of the plants which this author referred to the Tertiary may be Cretaceous

[1] Ettingshausen, Beiträge zur Kenntniss der fossilen Flora Neusellands. Denks. k. Akad. Wiss. Wien, Bd. liii, Ab. i, 1887, pp. 141-192, pls. i-ix.

[2] Park, J., The supposed Cretaceo-Tertiary of New Zealand, Geol. Mag., dec. v, vol. ix, 1912, pp. 491-498.

[3] Parks, James, The Geology of New Zealand, 1910.

[4] Marshall, P., Handbuch der Regionalen Geologie, vii, Bd. i, abt. 1911.

[5] See on this point Arber's comments in Proc. Cambridge Phil. Soc., vol. xvii, pt. 1, 1913, p. 126.

Stopes [1] recently described a petrified wood which may be of Upper Cretaceous age.

Aspidium cretaceo-zeelandicum Ettingshausen
Araucarioxylon novæ-zeelandii Stopes
Bambusites australis Ettingshausen
Casuarinites cretaceus Ettingshausen
Celastrophyllum australe Ettingshausen
Ceratopetalum rivulare Ettingshausen
Cinnamomum haastii Ettingshausen
Cupanites novæ-zeelandiæ Ettingshausen
Dacrydinium cupressinum Ettingshausen
Dalbergiophyllum nelsonicum Ettingshausen
Dalbergiophyllum rivulare Ettingshausen
Dammara mantelli Ettingshausen
Dicksonia pterioides Ettingshausen
Dryandroides pakawauica Ettingshausen
Dryophyllum nelsonicum Ettingshausen
Fagus nelsonica Ettinghausen
Fagus producta Ettinghausen
Ficus similis Ettingshausen
Flabellaria sublongirhachis Ettingshausen
Ginkgocladum novæzeelandiæ Ettinghausen
Gleichenia obscura Ettingshausen
Grewiopsis palæauica Ettingshausen
Haastia speciosa Ettingshausen
Knightiophyllum primævum Ettingshausen
Palæocassia phaseolitoides Ettingshausen
Poacites nelsonicus Ettingshausen
Podocarpium cupressinum Ettingshausen
Podocarpium tenuifolium Ettingshausen
Podocarpium ungeri Ettingshausen
Quercus calliprinoides Ettingshausen
Quercus nelsonica Ettingshausen
Quercus pachyphylla Ettingshausen
Sapindophyllum coriaceum Ettingshausen
Taxotorreya trinerva Ettingshausen
Ulmophylon latifolium Ettingshausen
Ulmophylon planeræfolium Ettingshausen.

[1] Stopes, M. C., A New Araucarioxylon from New Zealand. Annals of Botany, vol. xxviii, 1914, pp. 341-350, 3 tf., pl. xx.

NEW CALEDONIA

Lignites said to be partly Upper Cretaceous in age contain fragmentary plant remains which, according to Zeiller,[1] include the following:

Alnites
Cinnamomum
Podocarpium tenuifolium Ettingshausen
Podozamites cf. *latipennis* Heer
Sassafras or *Araliopsis*

The *Podozamites* would seem to confirm the Mesozoic age of these deposits, but since the so-called Cretaceous floras of New Zealand and Australia are in such an unsatisfactory condition they cannot afford facts for secure generalizations.

ASIA

Upper Cretaceous rocks continuing upward without observable unconformities from the Cenomanian into the Eocene are widely distributed in Japan. They are all, however, of marine, rather shallow-water, origin.

The only known fossil plants occur as petrified fragments in nodules imbedded in shale on the island of Hokkaido (Yezo).[2] The geology of this area has been discussed by Yabe.[3] The plants, very probably of Emscherian or slightly younger age, have been made known through the efforts of Stopes and Fujii,[4] the former author having made several contributions to this subject.[5] Suzuki[6] has also described an interesting petrified fungus as well as two new conifers from these rocks.

[1] Zeiller, R., Note sur quelques empreintes végétales des couches de charbon de la Nouvelle-Calédonie. Bull. Soc. Géol. France (sér. iii), tome xvii, 1889, pp. 443-446.

[2] Stopes, M. C., Plant-containing nodules from Japan. Quart. Jour. Geol. Soc. London, vol. lxv, 1909, pp. 195-205, pl. ix.

[3] Yabe, H., Jour. Coll. Sci. Imp. Univ. Tokyo, vol. xviii, 1903, pp. 1-55, pl. i-vii.

[4] Stopes, M. C., and Fujii, K., Studies on the Structure and Affinities of Cretaceous plants. Phil. Trans. Roy. Soc. London, vol. xx, B, 1910, pp. 1-90, pl. i-ix.

[5] Stopes, M. C., The Internal Anatomy of Nilssonia orientalis. Annals of Botany, vol. xxiv, 1910, pp. 389-393, tf. 1, pl. xxvi.

Stopes, M. C., and Kershaw, E. M., The Anatomy of Cretaceous Pine Leaves. *Ibidem*, pp. 395-402, pl. xxvii, xxviii.

Stopes, M. C., Further Observation on the Fossil Flower, Cretovarium. *Ibidem*, pp. 679-681, pl. lvi, lvii.

[6] Suzuki, Y., On the structure and affinities of two new conifers and a new fungus from the Upper Cretaceous of Hokkaido (Yezo), Bot. Mag., Tokyo, vol. xxiv, 1910, pp. 181-196, pl. vii.

The recorded plants are as follows:

Abiocaulis yezoensis Suzuki
Araucarioxylon tankoense Stopes and Fujii
Cedroxylon matsumuræ Stopes and Fujii
Cedroxylon yendoi Stopes and Fujii
Cretovarium japonicum Stopes and Fujii
Cryptomeriopsis antiqua Stopes and Fujii [1]
Cryptomeriopsis mesozoica Suzuki
Cunninghamiostrobus yubariensis Stopes and Fujii
Fagoxylon hokkaidense Stopes and Fujii
Fasciostelopteris tansleii Stopes and Fujii
Jugloxylon hamaoanum Stopes and Fujii
Nilssonia orientalis Heer
Niponophyllum cordaitiforme Stopes and Fujii
Petrosphæria japonica Stopes and Fujii
Pinus yezoensis Stopes and Kershaw
Pleosporites shirainus Suzuki
Populocaulus yezoensis Stopes and Fujii
Prepinus japonicus Stopes and Kershaw
Sabiocaulis sakuraii Stopes and Fujii
Saururopsis niponensis Stopes and Fujii
Schizæopteris mesozoica Stopes and Fujii
Yezonia vulgaris Stopes and Fujii [1]
Yezostrobus oliveri Stopes and Fujii

The foregoing include two fungi, two ferns, thirteen gymnosperms and six angiosperms, and are of unusual interest in being based upon anatomical material. No plants preserved as impressions have been described from this region, although it would seem certain that a near-shore shale, at least at some horizons, would abound in remains from the nearby land.

AFRICA [2]

The Nubian sandstone which various observers have recognized on the Sinai peninsula, in Syria [3] and Arabia evidently represents various geo-

[1] See remarks on these species by Jeffrey, Ann. of Bot., vol. xxiv, 1910, pp. 767-773, pl. lxv, who correlates the first with *Brachyphyllum* and the second with *Geinitzia* and maintains their araucarian nature. See also Fujii, K., Bot. Mag., Tokyo, vol. xxiv, 1910, pp. 197-220, and Stopes, M. C., Ann. of Bot., vol. xxv, 1911, pp. 269, 270.

[2] A good summary of the Cretaceous of Africa with bibliography is given by Krenkel, E., Die Entwickelung der Kreideformation auf dem afrikanischen Kontinente. Geol. Rundschau, Bd. ii, Heft 5/6, 1911, pp. 330-366.

[3] Day, A. E., The Age of the Nubian Sandstone. Congrès Géol. Internatl., Compterendu xii session, Canada, 1913, pp. 939-940, 1914.

logical horizons. According to Hume [1] it is of Carboniferous age on Sinai and in the Wady Araba. In the Nile valley and adjacent areas it is overlain by paleontologically recognizable Cenomanian deposits in the north and evidently represents the littoral sediments of a southwardly transgressing Cretaceous sea, since to the southward it represents both the Turonian and Emscherian, being directly overlain by fossiliferous beds of Campanian age. Leaf-bearing layers are mentioned in various official publications of the Egyptian Survey,[2] but if collections have ever been made they have never been submitted to a competent paleobotanist. In Heer's paper on the fossil fruits of the Kharga oasis (*op. cit.*) the following species are described:

Diospyros schweinfurthi Heer
Palmacites rimosus Heer
Royena desertorium Heer

These deposits are referred to the Danian by Ball,[3] who also refers *Nicolia ægyptiaca* Unger and *Araucarioxylon ægypticum* Schenck to the Campanian. Since the latter both occur in the determined Lower Oligocene east of Cairo, their existence in the Upper Cretaceous is extremely doubtful and denotes either incorrect determination or correlation. De Rozière [4] as early as 1826 mentioned a leaf impression resembling a sycamore in the sandstone near Assouan, and in 1910 Couyat [5] announced the discovery of a considerable collection of plants from the Nubian sandstone near this locality. A preliminary account of these plants by Couyat and Fritel [6] appeared that same year and a promised detailed account has not yet been published. They announce the presence of three monocotyledons, one a palm, and eight dicotyledons including *Juglandites,*

[1] Hume, W. F., Explanatory Notes to accompany the Geological Map of Egypt. Cairo, 1912.

[2] *E. g.*, in Survey Department, Paper No. 1, Cairo, 1907.

[3] Ball, John, Survey Dept. Rept., 1899. pt. ii, 1900.

[4] De Rozière, Description de l'Egypte, tome xxi, 1826, p. 12.,

[5] Couyat, J., Sur un nouveau gisement de feuilles fossiles en Egypte. Bull. Soc. géol., France, sér. 4, tome x, 1910, p. 29.

[6] Couyat, J., and Fritel, P. H., Sur la présence d'empreintes végétales dans le grès nubien des environs d'Assouan. Comptes rendus. Acad. Sci., tome cli, 1910, pp. 961-964.

Protoficus, two *Magnoliæ*, a *Liriodendropsis*, a lauraceous form, a rhamnaceous fruit, and considerable material of a new species, *Nelumbium schweinfurthi*.

From the Upper Cretaceous Mungo-schichten of the Kamerun in western Africa Menzel[1] has described traces of a small but interesting flora of very modern type. The species enumerated are:

Artocarpium guillemainii Menzel
Combretiphyllum acuminatum Menzel
Leguminosites albizzioides Menzel
Phyllites sp. Menzel

Kitson[2] mentions the extensive development of marine and estuarine Cretaceous in southern Nigeria. He collected rather fragmentary remains of plants, mostly dicotyledons. These are deposited in the British Museum and have thus far yielded one identifiable species, *Typhacites kitsoni*.[3]

Negri[4] has recently described the two following species, based on petrified wood, from what he calls the Middle Cretaceous of Tripoli:

Dadoxylon zuffardii
Protocedroxylon paronai

EUROPE

SWEDEN

The late Upper Cretaceous sea spread a mantle of marine, invertebrate-bearing sediments over the southern extremity of the Scandinavian peninsula. Many years ago Nilsson[5] described a small flora discovered in the greensand at Köpinge, Sweden.

[1] Menzel, P., Fossile Pflanzenreste aus den Mungo-schichten bei Kamerun. Abh. k. preuss. geol. Landes. Neue Folge. Heft 62, 1909, pp. 399-404, pl. ii.

[2] Kitson, A. E., Geographical Journal, Jan., 1913.

[3] Stopes, M. C., A new Cretaceous Plant from Nigeria. Geol. Mag. N. S. dec. 6, vol. i, pp. 433-435, tf. 1, pl. xxxiii, 1914.

[4] Negri. G. Sopra alcumi legni fossili dell Gebel Tripolitano. Boll. Soc. Geol. Ital., vol. xxxiii, 1914, pp. 321-344, pls. v, vi.

[5] Nilsson, S., Sur quelques végétaux terrestres fossiles, qui se trouvent dans le grès vert en Scanie. Kgl. Svenska.-Akad. Handl. Bd. i, 1824.
Nilsson, S., Petrificata suecana formationis cretaceæ. Lund, 1827.

With the exception of the few woods described by Conwentz[1] no recent additions have been made to the Cretaceous floras of Sweden. The following species are recorded:[2]

Acerites ? cretaceus Nilsson
Alnites ? friesii Nilsson
Comptonites ? antiquus Nilsson
Cycadites nilssonianus Brongniart[3]
Pinus nathorsti Conwentz
Salicites ? wahlbergii Nilsson
Weichselia erratica Conwentz

ENGLAND

In England the whole of the Upper Cretaceous is of typically marine origin and consequently has not yielded any land plants except a few fir cones, drift wood and rare and fragmentary leaves of dicotyledons in the Lower Chalk. These have been mentioned in a few scattered papers,[4] and as the British Museum has recently undertaken a report on Cretaceous floras[5] no attempt will be made to list the few and unsatisfactory forms in the literature, especially since in their present state they offer nothing of either botanical or geological significance.

[1] Conwentz, H., Untersuchungen über fossile Holzer Schwedens. Kgl. Svenska Vetens. Akad. Handl. Bd. xxiv, 1891.

[2] List copied from Brongniart, A., Tableau, 1849, p. 111.

[3] Nathorst in his Geology of Sweden figures this form, referring it to the genus *Dewalquea*.

[4] Nathorst in his Geology of Sweden figures this form, referring it to the tion of the southeast of England. Quart. Jour. Geol. Soc., London, vol. ii, 1846, pp. 51-54, pl. ii.

[4] Mantell, G. A., Description of some Fossil Fruits from the Chalk Forma-Upper Greensand of Shaftesbury in Dorsetshire. Geol. Mag., vol. ii, 1865, pp. 484-487, pl. xiii.

——— The Plant Remains of the Upper and Lower Cretaceous (Neocomian) Formations in England. In Dixon's Geology of Sussex, ed. ii, 1878, pp. 277-282.

Gardner, J. S., On Fossil Flowering or Phanerogamous Plants. Geol. Mag., dec. 3, vol. iii, 1886, pp. 495-503. Also, Rept. Brit. Assn., Birmingham, pp. 241-250 and plate.

[5] Stopes, M. C., Catalogue of the Mesozoic Plants in the British Museum (Nat. Hist.). The Cretaceous Flora, part i, Bibliography, Algæ and Fungi, London, 1913.

FRANCE

In contrast with both older and younger horizons the Upper Cretaceous of France is relatively poor in plant remains including, as it does, only the small florules of the Cenomanian of Anjou, the Argonne, and the Ile d'Aix; the Turonian of Bagnols and Mède near Les Martigues (Var); the Emscherian of Beausset near Toulon; and the Aturian of the lignites of Fuveau (Bouches-du-Rhône).

The contention that the Sabalites sandstone which is widespread in western France is of Senonian age was vigorously maintained by Welsch.[1] This sandstone has been shown by Bigot[2] to be underlain at Fyé by Eocene, and it is now commonly referred to the Bartonian. The flora is considerable and has been described in numerous papers by Crié.

Following are lists of the plants recorded from the Upper Cretaceous:

Cenomanian

Brongniart[3] in 1823 described the following indefinite remains from the Ile d'Aix near La Rochelle:

Fucoides strictus Brongniart
Fucoides tuberculosus Brongniart
Zosterites bellovisana Brongniart
Zosterites cauliniæfolia Brongniart
Zosterites elongata Brongniart
Zosterites lineata Brongniart
Zosterites orbigniana Brongniart

The latter five supposed forms of *Zosterites* were united in a single species by both Unger (1850) and Schimper (1870). Crié[4] in 1890 added descriptions of the two following species based on the petrified wood to the foregoing meager list:

Araucarioxylon gardoniense Crié
Cedroxylon gardoniense Crié

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[1] Welsch, J., Sur l'âge Senonien des grès à Sabalites andegavensis de l'ouest de la France. Comptes rendus Acad. Sci., tome cxxv, 1897, pp. 667-669.

[2] Bigot, A., Bull. Soc. géol. de France (iii), tome xxv, 1897, p. 876.

[3] Brongniart, A., Observations sur le Fucoïdes et quelques autres plantes marines fossiles. Mém. Soc. Hist. nat. de Paris, tome i, 1823, p. 315, pl. xxi, figs. 5-8.

[4] Crié, L., Recherches sur les végétaux fossiles de l'Ile d'Aix (Charente Inférieure) Ann. Soc. Sci. Nat. Charente Infér. No. 26, 1890, pp. 231-237, pls. i, ii.

Rothpletz has described *Lithothamnium cenomanicum* from these sandstones.

The Cenomanian of the Argonne (St. Mènehould) has furnished to Fliche[1] a small but important flora based largely on fruits and petrified wood. The following species are represented:

Araucaria cretacea Brongniart[2]
Astrocaryopsis saintæ-manehildæ Fliche (palm fruit)
Cedroxylon manehildense Fliche
Cocoopsis ovata Fliche (palm fruit)
Cocoopsis zeilleri Fliche (palm fruit)
Laurus colleti Fliche (leaf)
Mammæites francheti Fliche (seed of *Cluisiaceæ*)

Turonian

The flora of this stage is represented by the petrified woods from Anjou described by Crié,[3] and by the rather extensive but largely unstudied plants from near Marseilles (Var) discussed by Saporta,[4] Vasseur,[5] Marion,[6] and Laurent.[7]

[1] Fliche, P., Sur une Dicotylédone trouvée dans l'albien supérieur aux environs de Sainte-Mènehould (Marne). Comptesrendus, 9 Mai, 1892.

——— Sur des fruits de Palmiers trouvés dans le Cénomanien aux environs de Sainte-Mènehould. Comptes rendus 16 Avril, 1894.

——— Etudes sur la flore fossile de l'Argonne (Albien-cénomanien). Bull. Soc. Sci. Nancy, 1896, 196 pp., 17 pls.

[2] Cone described by Brongniart *(op. cit.)* from Eure-et-Loire.

[3] Crié, L., Bull. Soc. d'Etudes Sci. d'Angers, tome xxi, 1891.

——— Recherches sur les Palmiers silicifiés des terrains Crétacés de l'Anjou. *Ibidem*, tome xxi, 1892, pp. 97-103, pl. i, ii.

[4] Saporta, G. de, Communication à propos des empreintes végétales trouvées dans la course des Martigues. Bull. Soc. géol. Fr. (ii), tome xxi, 1864, pp. 499-502.

——— Le Monde des Plantes avant l'apparition de l'homme, Paris, 1879, p. 198.

[5] Vasseur, G., Découverte d'une flore turonienne dans les environs des Martigues (Bouches-du-Rhône). Comptes rendus, 27 mai, 1890.

[6] Marion, A. F., Sur la flore turonienne des Martigues (Bouches-du-Rhône). Comptes rendus, tome cx, 1890, pp. 1052-1055.

[7] The writer is indebted to Prof. L. Laurent of Marseilles for a provisional list of the forms from this horizon contained in the Muséum d'histoire naturelle de Marseille.

Combining the identifications of the students mentioned above furnishes the following list of Turonian plants, which while incomplete is of the utmost importance in discussing the correlation of the Upper Cretaceous flora of the Atlantic Coastal Plain.

Araucaria toucasi Saporta
Artocarpus [7]
Caesalpinites marticensis Marion
Celastrophyllum [6]
Ceratostrobus sequoiæphyllun Velenovsky ?
Chamæcyparites [7]
Chondrophyton dissectum Saporta and Marion [1]
Comptoniopteris intermedia Marion
Comptoniopteris provincialis Marion
Comptoniopteris saportæ Marion
Comptoniopteris vasseuri Marion
Cupressoxylon hosii Crié
Cyparissidium gracile Heer
Dewalquea (2 spp.) [6]
Dracænites jourdei Marion
Dryophyllum ? [6]
Euphorbiophyllum antiquum Saporta and Marion [1]
Frenelopsis hoheneggeri Schenk
Gleichenia delicatula Heer
Gleichenia zippei (Corda) Heer
Laurus proeatavia Saporta and Marion [7]
Libocedrus sp. nov. [6]
Lomatopteris superstes Saporta
Magnolia telonensis Saporta
Melastomites [7]
Menispermum (Cocculus) assimile Marion
Myrica campei Marion
Myrica gaudryi Marion
Myrica rougoni Marion
Palmoxylon andegavense Crié
Palmoxylon guillieri Crié
Palmoxylon ligerianum Crié
Podozamites lanceolatus Heer
Polytænia quinquesecta Saporta and Marion [5]
Proteophyllum [6]
Rhus [7]
Salix vasseuri Marion
Sapindophyllum (2 spp.) [6]
Scleropteris [7]

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[1] Saporta and Marion, L'Evolution du Règne Végétal. Les Phanérogames, tome ii, 1885, pp. 117-120.

Sequoia heterophylla Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Sphenolepis kurriana Schenk ?[7]
Sphenolepis sternbergiana Schenk ?[7]
Styrax (2 spp.)[6]
Thuyites sp. nov.[6]
Viburnum[6]
Widdringtonites reichii (Ettingshausen) Heer (twigs and 4-valved cone)

Emscherian

The long-known plant beds of Beausset near Toulon from which Saporta[1] identified several species were long considered of Turonian age but are now considered to be referable to the Lower Senonian. The following species have been recognized:

Araucaria toucasi Saporta
Cyparissidium gracile Heer
Lithothamnium amphiroaformis Rothpletz
Lithothamnium gosaviense Rothpletz
Lithothamnium palmatum (Goldfuss) Gümbel
Lithothamnium racemosum (Goldfuss) Gümbel
Lithothamnium turonicum Rothpletz
Lomatopteris schimperi Schenk
Magnolia telonensis Saporta
Zosterites loryi Fliche[2]

Aturian[3]

The lignites of Fuveau which have been worked commercially for so long have furnished the following flora, described by Saporta:[4]

Abietites (seed)
Anacardites alnifolius Saporta
Carpolithus curtus Saporta

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[1] Saporta, G. de, Le Monde des Plantes avant l'apparition de l'homme. Paris, 1879, p. 198.

[2] From Dévolny. Fliche, P., Note sur un Zosterites trouvé dans le crétacé supérieur du Dévolny. Soc. Géol. Fr. (iv), tome ii, 1902, pp. 112-127, pl. ii.

[3] Campanian according to Saporta (1890).

[4] Saporta, G. de, Flore des lignites inférieurs, en étage à lignite proprement dit. Ann. Sci. Nat. botanique. 4 sér., tome xvii, 1862, pp. 191-202. (Etudes, tome i, 1863, livre iii, pp. 38-49, pl. i; pl. ii, fig. 1.)

——— Le Nelumbium provinciale des lignites crétacés de Fuveau en Provence. Mém. Soc. Géol. Fr., Paléont. Mem. No. 5, pp. 1-10, pl. i-iii (12-14), 1890.

Carpolithus provincialis Saporta [1]
Filicites lacerus Saporta
Filicites vedensis Saporta
Flabellaria longirachis Unger
Frenelopsis hoheneggeri Schenk
Nelumbium provinciale Saporta
Osmunda gerini Saporta
Phyllites obscurus Saporta
Phyllites tenuis Saporta
Pinus oxyptera Saporta
Pistia mazeli Saporta and Marion [2]
Rhizocaulon macrophyllum Saporta
Rhizocaulon subtilinervium Saporta
Sequoia reichenbachi (Geinitz) Heer (*Geinitzia cretacea* Endlicher)
Typhacites lævis Saporta
Typhacites rugosa Saporta

PORTUGAL

The writer has already commented [3] on the paleobotanical importance of the Mesozoic section in Portugal. Saporta's great work,[4] the last important contribution from his pen, fully treated of the late Jurassic and the various Lower Cretaceous floras. The considerable flora from Nazareth described in that volume (pp. 198-219) and referred to the upper Albian (Vraconnian) has since been shown to be of Cenomanian age. Large collections from later Cretaceous horizons in Saporta's possession at the time of his death have never been described except in the short paper by De Lima [5] published in 1900. From this work it appears that there is a considerable flora from various horizons in the Upper Cretaceous, namely, the flora recorded from Bussaco, which Choffat has shown to be Turonian, and the plants collected at Casal dos Bernardos, Vizo, Bizarros, Mira, and S. Pedro de Murcella, which are of Senonian age (probably Emscherian).

[1] Not related to *Nipadites* in the judgment of the writer.

[2] Saporta and Marion. L'Evolution du Règne Végétal. Les Phanérogames, tome ii, 1885, p. 37.

[3] Berry, E. W., Md. Geol. Survey, Low. Cretaceous, 1911, p. 103.

[4] Saporta, G. de, Fl. Foss. Portugal. Trav. Geol. Port., Lisbon, 1894.

[5] De Lima, W., Noticia sobre algum vegetaes fosseis da flora senomiana (sensulato) do solo Portuguez communicacoes de Direccao dos servicos geologicos de Portugal, tome iv, 1900, pp. 1-12.

Cenomanian

The Cenomanian flora coming from Nazareth, Alcantara (Ratão, Campolide) and Padrão includes the following:

Brachyphyllum corallinum Heer
Branchphyllum obesum Heer
Carpites granulatus Saporta
Caulomorpha heeri Saporta
Chondrophyton laceratum Saporta
Chondrophyton obscuratum Saporta
Ctenidium integerrimum Heer
Czekanowskia nervosa Heer
Eucalyptus angusta Saporta
Eucalyptus choffati Saporta
Eucalyptus proto-geinitzi Saporta
Euphorbiophyllum primordiale Saporta
Frenelopsis occidentalis Heer
Laurus attenuata Saporta
Laurus notandia Saporta
Laurus palæocretacea Saporta
Leguminosites infracretacicus Saporta
Myrica gracilior Saporta
Myrica lacera Saporta
Myrica revisenda Saporta
Myrsinophyllum venulosum Saporta
Olea ? myricoides Saporta
Palæolepis cheiromorpha Saporta
Palæolepis multipartita Saporta
Phyllites inflexinervis Saporta
Phyllites triplinervis Saporta
Phyllotænia demersa Saporta
Phyllotænia elongata Saporta
Phyllotænia nervosa Saporta
Phyllotænia stipulacea Saporta
Podozamites alcantarina Saporta
Proteophyllum daphnoides Saporta
Proteophyllum demersum Saporta
Proteophyllum oblongatum Saporta
Proteophyllum truncatum Saporta
Ravenalospermum incertissimum Saporta
Salix assimilis Saporta
Sapindophyllum brevior Saporta
Sapindophyllum subapiculatum Saporta
Sequoia lusitanica Heer
Sphenolepis kurriana (Dunker) Schenk
Viburnum vetus Saporta

Turonian

The flora from the Turonian comes from Bussaco and includes but three species (Saporta, *op. cit.*, pp. 221-222). These are:

Magnolia palæocretacica Saporta
Phyllotænia costulata Saporta
Sphenopteris angustiloba Heer

Senonian

The Senonian flora (probably Emscherian) noticed by De Lima (*op. cit.*), but not described in detail, is said to include the following:

Aristolochia
Cinnamomum cf. *sezannense* Watelet
Cornus
Credneria
Dewalquea haldemiana Saporta and Marion
Dewalquea insignis Hosius and von der Marck
Diospyros
Echinostrobus
Echitonium
Eucalyptus (leaves)
Eucalyptus (fruits = *Dammara?*)
Flabellaria (= *Sabalites*)
Fraxinus (fruits)
Frenelopsis occidentalis Heer
Glyptostrobus cf. *debilis*
Laricopsis
Laurus
Magnolia
Myrica
Nelumbium
Phlebomeris cf. *spectanda* Saporta
Phlebomeris cf. *willkoni* Saporta
Pinus
Protophyllum
Quercus (24 spp.)
Rhamnus cf. *alaternoides*
Sassafras cf. *cretacea*
Sequoia cf. *fastigiata* (Sternberg) Heer
Sequoia cf. *reichenbachi* (Geinitz) Heer
Sequoia subulata Heer
Sphenolepis sp. nov.
Sphenopteris mantelli Brongniart ?
Sphenopteris cf. *plurinervia* Heer
Zamia (fruit)
Zizyphus

Choffat[1] has recently announced the completion of a monograph including these Upper Cretaceous floras for the Portuguese Survey by Laurent of Marseilles, which unfortunately will not be published for some time because of lack of funds.

ITALY

Aside from the various so-called fucoids, such as *Halimenites, Chrondrites, Gleichenophycos, Paleodyction,* etc., described from the Cretaceous rocks of the Alps and the Apennines, the Upper Cretaceous flora of Italy is almost negligible. In connection with the elaboration of the invertebrate faunas of Vernasso near San Pietro in Venetia by Tommasi[2] several fossil plants were discovered. Bozzi[3] in 1888 enumerated five species from Vernasso in Friuli (Venetia). Three years later the same author published a more complete paper[4] on the same subject. In a paper on the fossils of the Senonian of the central Apennines Bonarelli[5] describes and figures as *Calamitopsis*[6] (p. 1025, pl. v, fig. 8) an entirely worthless specimen. Following is a list of the forms described from Vernasso:

Araucaria macrophylla Bozzi (*latifolia* Bozzi)
Arundo groenlandica Heer
Cunninghamites elegans (Corda) Endlicher
Cyparissidium gracile Heer
Frenelopsis königii Hosius
Myrica vernassiensis Bozzi
Phyllites proteaceus Bozzi
Phyllites platanoides Bozzi
Rhus antiqua Bozzi (*cretacea* Bozzi)
Sequoia ambigua Heer
Sequoia concinna Heer

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[1] Choffat, P., O servico geológico de Portugal em 1914, p. xxi (17).

[2] Tommasi, A., Fossili Senoniani di Vernasso presso S. Pietro al Natisone. Atti Instit. Veneto Sci. (vol. xxxviii), vol. ii, 1892, pp. 1089-1122, pls. unnumbered (fossil plants, p. 1119).

[3] Bozzi, L., La Flora Cretacea di Vernasso nel Friuli. Bol. Soc. Geol. Ital., Atti, vol. xxxi, 1888, pp. 399-405, pl. vi.

[4] Bozzi, L., La Flora Cretacea di Vernasso nel Friuli. Bol. Soc. Geol. Ital., vol. x, 1891, pp. 371-382, pl. xv, xvi.

[5] Bonarelli, G., I fossili senoniani dell' Apennino centrale che si conservano a Perugia nella collezione Bellucci. Atti R. Accad. Sci. Torino, vol. xxxiv, 1899, pp. 1020-1027, 1 pl.

[6] This may be the *Frenelopsis Königii* of Hosius.

This small florule is hardly sufficient for exact correlation. It is not, however, as old as the Cenomanian or as young as the Aturian, and is probably Coniacian (*i. e.,* Lower Emscherian).

GERMANY

The German Empire comprises so many subordinate political divisions whose boundaries have shifted to such an extent that any treatment of the fossil floras by political divisions is unsatisfactory. Perhaps the most satisfactory areal division of the Upper Cretaceous in this region is that adopted by Kayser [1] who discusses briefly the following areas:

(1) The small area of Senonian (Emscherian-Maestrichtian) around Aachen (Aix-la-Chapelle) and Maestricht on the Belgian-Holland border of Rhenish Prussia.

(2) The Northwest German or Lower Saxon area. This embraces the region north of the lower Rhein Schiefergebirges and the Hartz, extending from the Rhein to the Elbe. It includes the so-called Westphalian Cretaceous basin, the Teutoburger Wald, the Wesergebirge and the "subhercynischen" Cretaceous in the vicinity of Hannover, Braunschweig, Goslar and Halberstadt.

(3) The Saxon-Bohemian area. This includes the extensively developed Upper Cretaceous of northern Bohemia and in Germany comprises the region from the Elbsandsteingebirge in Saxony to Löwenberg and other places in Lower Silesia, as well as the country around Bayreuth, Amberg, Regensberg, etc., southwest of the Böhmerwald.

(4) The Upper Silesian area around Appeln and Leobschütz.

(5) The Baltic area in Pommern, Mecklenburg, Holstein, bei Lüneburg.

(6) The Prussian Cretaceous area widely spread in East and West Prussia.

The first three of the foregoing are very important paleobotanically, while the last three are of practically no interest to the paleobotanist. The Saxon-Bohemian area is so much more extensively developed southeast of

[1] Kayser, Formationskunde, ed. 5, 1913, p. 521.

the Erzgebirge and the study of its flora has, with the exception of Gœppert's early work in Silesia, been prosecuted almost entirely in Bohemia that its discussion falls naturally with that of the latter country.

Rhenish Prussia

The small Cretaceous area around Aachen (Aix-la-Chapelle) on the Holland-Belgian frontier of the Rhein province and extending across the border into Limburg and Lüttich, comprises littoral strand and dune sands overlain by the greensands, marls and calcareous beds (the so-called tuffs) of the advancing Upper Cretaceous sea. The deposits rest on Carboniferous or Upper Devonian rocks and show the following section:[1]

Maestrichtian[2]—Sandy glauconitic marls with a rich bryozan fauna, mosasaurs, chelonians, dinosaurs, echinoids and molluscs (zone of *Belemnitella mucronata*[3]).
Marls with flints, carrying *Gryphæa*, *Crania*, *Nautilus*, etc.

Santonian or Campanian—Greensand with a rich marine fauna (zone of *Actinocamax quadratus*).
Aachener sand with lenses of laminated plant-bearing clay, and containing silicified wood and a shallow-water marine fauna—*Ostreideæ*,[4] (*Exogyra laciniata*, etc.), *Inoceramus lobatus*, *Actæonella*, *Pyrgulifera*, etc.

The fossil plants in the basal Campanian (or Santonian) come from in and around Aachen (*sables d'Aix-la-Chapelle*), from the vicinity of Maestricht about 27 kilometers northwest of Aachen in the province of Limburg in Holland, and south and west of Aachen in Herve and Lüttich in Belgium. Fossil plants have been known from these sands since the early days of paleobotany, Schlotheim having mentioned fossil-wood, cone-scales and dicotyledonous fruits from Aachen. (Petrefactenkunde, 1820-1823.)

[1] von Dechen, Erlauterungen zur Geol. Karte der Rheinprovinz und der Provinz Westphalen, Bd. ii, 1872, pp. 424-442.
[2] The younger Danian lacks *Belemnitella*.
[3] Holzapfel, Palæontographica, 1887-1889.
[4] Referred by many students (*e. g.*, de Lapparent) to the Santonian.

The flora received its first systematic treatment by Gœppert[1] in 1841. Debey, who greatly interested himself in collecting the vegetable remains from these beds, was a practising physician in Aachen for many years and amassed large collections which unfortunately became scattered after his death. He commenced publishing[2] in 1848, and with the collaboration of Ettingshausen[3] succeeded in 1856 and 1859 in placing the *Thallophyta* and *Pteridophyta* in a condition which made them available to students of paleobotany. Then followed a period of eighteen years during which he published nothing. In 1877 there appeared[4] a short paper on coniferous remains and in 1880 another short paper[5] was devoted to the oak-like dicotyledons (*Dryophyllum*). Meanwhile in 1849 Pomel[6] had

[1] Gœppert, Fossile Pflanzenreste des Eisensandes von Aachen, als zweiter Beitrag zur flora der Tertiärgebilde. Nova Acta Acad. Leop.-Carol., Bd. xix, Pt. 2, 1841, pp. 139-160, pl. liv.

[2] Debey, Uebersicht der urweltlichen Pflanzen des Kreidegebirges überhaupt, und der Aachener Kreideschichten insbesondere. Verhandl. naturhist. Ver. preuss. Rheinl., Westfalens, Bd. v, Jahrg. 1848, pp. 113-125.

Debey, Ueber eine neue Gattung urweltlicher Coniferen aus dem Eisensand der Aachener Kreide. *Ibidem*, pp. 126-142.

Debey, Entwurf zu einer geognostisch-geogenetischen Darstellung der Gegend von Aachen. Bericht 25. Versamml. deutsch. Naturf., 1849, pp. 269-328, pl. iv (sections).

Geinitz, Bemerkungen zu Debey's Entwurf etc., Neues Jahrb., 1850, pp. 289-301.

Debey, Beitrag zur fossilen Flora der holländischen Kreide (Væls bei Aachen, Kunraed, Maestricht). Verhandl. naturhist, Ver. preuss. Rheinl., Westphalens, Bd. viii, Jahrg. 1851, pp. 568-569.

[3] Debey u. Ettingshausen, Uebersicht der gesammter Aachener and Maestrichter Kreideflora. Bericht 32. Versamml. deutsch. Naturfor., 1856.

Debey u. Ettingshausen, Die Urweltlichen Thallophyten des Kreidegebirges von Aachen und Mæstricht. Denks. k. Akad. Wiss. Wien, math.-nat. Cl. Bd. xvi, 1859, pp. 131-214, pl. 1-3.

Debey and Ettingshausen, Die Urweltlichen Acrobryen des Kreidegebirges von Aachen und Maestricht. *Ibidem*, Bd. xvii, 1859, pp. 183-248, pl. i-vii.

[4] Debey, Eine Uebersicht der fossilen Coniferen der Aachener Kreide. Verhandl. naturhist. Ver. preuss. Rheinl., Westfalens, Corr.-Blatt., Bd. xxxiv, 1877, p. 110.

[5] Debey, Sur les feuilles querciformes des sables d'Aix-la-Chapelle. Compte rendu du Congrès de botanique et d'horticulture, 1880, pt. ii, Bruxelles, 1881, pp. 1-16, pl. 1.

[6] Pomel, Matériaux pour servir à la flore fossile des terrains jurassiques de la France. Bericht 25. Versamml. deutsch. Naturfor., 1849.

described a single species from this area and in 1853 Miquel[1] published an account of the plants from beds of this age in Limburg, and Bosquet[2] in 1861 and 1866 listed the plants from Limburg and the adjacent region in Belgium. Nothing further has appeared except a short paper by Lange[3] in 1890 who described a collection of Aachen plants in the Leipzig Museum which had been presented to Schenk many years before by Debey.

Combining the very uneven and for the most part unsatisfactory work of these various students results in the following list of species:

Æcidites stellatus Debey and Ettingshausen
Adiantites cassebeeroides Debey and Ettingshausen
Adiantites decaisneanum Debey and Ettingshausen
Araucarites miqueli Debey
Asplenium brongniarti Debey and Ettingshausen
Asplenium cœnopteroides Debey and Ettingshausen
Asplenium fœrsteri Debey and Ettingshausen
Belodendron gracilis Debey
Belodendron lepidodendroides Debey
Belodendron neesii Debey
Benizia calopteris Debey and Ettingshausen
Bonaventurea cardinalis Debey and Ettingshausen
Bowerbankia attenuata Debey
Bowerbankia emarginata Debey
Bowerbankia maxima Debey
Bowerbankia repanda Debey
Bowerbankia rotundifolia Debey
Carolopteris aquensis Debey and Ettingshausen
Carolopteris asplenioides Debey and Ettingshausen
Carpolithus hemlocinus Schlotheim (= *Sequoia* sp.)
Caulerpites bryoides Debey and Ettingshausen
Caulinia mulleri Pomel

[1] Miquel, De fossiele planten van het Krijt in het hertogdom Limburg. Verhandl. Geol. Kaart Nederl., vol. i, Haarlem, 1853, pp. 33-56, pl. i-vii.

[2] Bosquet, Coup d'œil sur la répartition géologique et géographique des espèces d'animaux et de végétaux citées dans le tableau des fossiles crétacés du Limbourg inséré dans la dernière livraison de l'ouvrage du Dr. W. C. H. Staring sur le sol de la Néerlande. Verslag. k. Akad. Wet. Naturk., vol. xi, Amsterdam, 1861, pp. 108-120.

Bosquet, Fossiele fauna en flora van het Krijt van Limburg. In Staring, Bodem van Nederland, vol. ii, Amsterdam, 1866, pp. 414-418 (plants).

[3] Lange, Beiträge zur Kenntniss der Flora des Aachener Sandes. Zeits. deutsch. geol. Gesell., Bd. xlii, 1890, pp. 658-676, pl. xxxii-xxxiv.

Chondrites bosqueti Miquel
Chondrites riemsdyki Miquel
Chondrites divaricatus Debey and Ettingshausen
Chondrites elegans Debey and Ettingshausen
Chondrites jugiformis Debey and Ettingshausen
Chondrites riemsdyki Miquel
Chondrites rigidus Debey and Ettingshausen
Chondrites subintricatus Debey and Ettingshausen
Chondrites vagus Debey and Ettingshausen
Confervites aquensis Debey and Ettingshausen
Confervites cæspitosus Debey and Ettingshausen
Culmites cretaceus Miquel
Cunninghamites squamosus Heer
Cupressinoxylon ucranicum Gœppert
Cycadopsis aquisgranensis Debey = *Sequoia reichenbachi*
Cycadopsis araucarina Debey = *Sequoia reichenbachi*
Cycadopsis cryptomerioides Miquel
Cycadopsis fœrsteri Debey = *Sequoia reichenbachi*
Cycadopsis monheimi Debey = *Cunninghamites squamosus*
Cycadopsis ritzi Debey = *Cunninghamites squamosus*
Cycadopsis thuyoides Debey = *Sequoia reichenbachi*
Cylindrites ? cretaceus Miquel
Danæites schlotheimi Debey and Ettingshausen
Debeya serrata Miquel
Delesserites thierensi Debey
Didymosorus comptoniifolius Debey and Ettingshausen
Didymosorus gleichenioides Debey and Ettingshausen
Didymosorus varians Debey and Ettingshausen
Dewalquea aquisgranensis Saporta and Marion (*Grevillea palmata* Debey *in litt.*)
Dewalquea insignis Hosius and von der Marck
Dryophyllum alberti-magni Debey
Dryophyllum aquisgranense Debey
Dryophyllum benthianum Debey
Dryophyllum campteroneurum Debey
Dryophyllum crepini Debey
Dryophyllum lerschianum Debey
Dryophyllum dethimusianum Debey
Dryophyllum œdrys Debey
Dryophyllum exiguum Debey
Dryophyllum gracile Debey
Dryophyllum heeri Debey
Dryophyllum lerschianam Debey
Dryophyllum lesquereuxianum Debey
Dryophyllum regaliaquense Debey
Dryophyllum tenuifolium Debey
Eucalyptus nov. spec. Debey (*in litt.*)

Ficus gracilis Hosius
Gelidinium trajecto-mosanum Debey and Ettingshausen
Gleichenia protogæa Debey and Ettingshausen
Haliserites gracilis Debey and Ettingshausen
Halocharis longifolia Miquel
Himantites alopecurus Debey and Ettingshausen
Hysterites dubius Debey and Ettingshausen
Laminarites polystigma Debey and Ettingshausen
Laurophyllum aquisgranense Lange
Lochmophycus caulerpoides Debey and Ettingshausen
Lygodium cretaceum Debey and Ettingshausen
Melophytum cyclostigma Debey and Ettingshausen
Mitropicea decheni Debey
Mitropicea noeggerathi Debey
Monheimia aquisgranensis Debey and Ettingshausen
Monheimia polypodioides Debey and Ettingshausen
Moriconia cyclotoxon Debey and Ettingshausen
Muscites cretaceus Debey and Ettingshausen
Myricophyllum asplenioides Lange
Myricophyllum haldemianum Hosius and von der Marck
Nechalea lobata Debey
Nechalea petiolata Debey
Nechalea serrata Debey
Neurosporangium foliaceum Debey and Ettingshausen
Neurosporangium undulatum Debey and Ettingshausen
Nicolia ægyptica Unger
Opegraphites striato-punctatus Debey
Palmocarpum cretaceum Miquel
Phycodes sericeus Debey and Ettingshausen
Phyllites lævigatus Miquel
Phyllites monocotyledonea Miquel
Phyllites sinuatus Lange
Phyllites sp., Lange
Pinites patens Miquel
Pteridoleimma aneimiifolium Debey and Ettingshausen
Pteridoleimma antiquum Debey and Ettingshausen
Pteridoleimma arborescens Debey and Ettingshausen
Pteridoleimma benincasæ Debey and Ettingshausen
Pteridoleimma deperditum Debey and Ettingshausen
Pteridoleimma dictyodes Debey and Ettingshausen
Pteridoleimma dubium Debey and Ettingshausen
Pteridoleimma elisabethæ Debey and Ettingshausen
Pteridoleimma gymnorachis Debey and Ettingshausen
Pteridoleimma haidingeri Debey and Ettingshausen
Pteridoleimma hessianum Debey and Ettingshausen

Pteridoleimma kaltenbachi Debey and Ettingshausen
Pteridoleimma koninckianum Debey and Ettingshausen
Pteridoleimma leptophyllum Debey and Ettingshausen
Pteridoleimma michelisi Debey and Ettingshausen
Pteridoleimma odontopteroides Debey and Ettingshausen
Pteridoleimma orthophyllum Debey and Ettingshausen
Pteridoleimma pecopteroides Debey and Ettingshausen
Pteridoleimma pseudadianthum Debey and Ettingshausen
Pteridoleimma ritzianum Debey and Ettingshausen
Pteridoleimma serresi Debey and Ettingshausen
Pteridoleimma waterkeyni Debey and Ettingshausen
Raphaelia neuropteroides Debey and Ettingshausen
Rhacoglossum dentatum Debey
Rhacoglossum heterophyllum Debey
Sequoia reichenbachi (Geinitz) Heer
Sphærites solitarius Debey and Ettingshausen
Thallasocharis bosqueti Miquel
Thallasocharis mulleri Debey
Zonopteris gœpperti Debey and Ettingshausen
Zosterites æquinervis Debey
Zosterites miqueli Debey
Zosterites vittata Debey

Saxony

THE HARTZ REGION.—North of the Hartz the lower Saxon, or subhercynian Cretaceous area, contains fossil plants in the vicinity of Blankenburg, Quedlinburg, Halberstadt, etc.[1] Although known for over a century the first author to figure fossil plants from the now celebrated beds of Blankenburg and vicinity was Zenker,[2] who in 1833 described a *Salix* and four species of *Credneria*. A rather extensive literature, principally geological, has grown up around these deposits. The principal

[1] In this area Liassic plants have been described by Dunker from the Halberstadt region, Palæont., Bd. i, 1846-1851, pp. 39-41, 107-125, pl. vi, xiii-xvii Nachträge, pp. 176-181, 319, 320, pl. xxv, xxxvii, and Lower Cretaceous plants have been described from the Quedlinburg region from the Neocomian sandstone of Helmstein bei Westerhausen and from the Aptian (Dames, 1880) of Langenberge (sometimes considered of Albian age [Ewald, 1857]), noticed by Schulze in 1888 (Inaugural Dissert. Halle) and thoroughly described by Richter in 1906 and 1909.

[2] Zenker, J. C., Beiträge zur Naturgeschichte der Urwelt, Jena, 1833.

paleobotanical contributions have been by Hampe,[1] Dunker,[2] Stiehler,[3] Heer,[4] Schulze,[5] Lampe,[6] and Richter.[7] In 1884 Vater[8] worked over a large collection of petrified woods from the so-called Phosphoritlager von Harzburg und der Helmstedter Mulde. These woods are obviously all or in part reworked in the Oligocene deposits in which they are found, and Vater concluded that they came from the Upper Cretaceous or older rocks of the region. Nineteen species were differentiated and these are all included in the following list, although in the case of forms like *Fegonium, Tœnioxylon,* etc., their exact age is uncertain.

There has been considerable discussion regarding the exact correlation of these beds with the more fossiliferous horizons of Rhenish Prussia and Westphalia. Schulze in 1888 enumerated the following four horizons:

Ilsenburgmergel
Heimburggestein
Subhercynischen Senonquader
Salzberggestein

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[1] Hampe, E., Vortrag über Petrefacten der Kreideformation (Quadersandstein) bei Blankenburg., Bericht. naturwiss. Vereins Harzes, 1852, pp. 6-7.
Ibidem, 1853-54, p. 12.

[2] Dunker, W., Ueber mehre Pflanzenreste aus dem Quadersandstein von Blankenburg, Palæont., Bd. iv, 1856, pp. 179-183, pl. xxxii-xxxv.

[3] Stiehler, A. W., Ueber fossile Pflanzen aus der Kreideformation von Quedlinburg, Bericht. Deutsch. Naturf. Vers. Bd. xxxi, 1854, pp. 69-71.

Die Flora im Quadersandstein des Langenberges bei Quedlinburg, Zeits. Naturwiss. Halle, Bd. ix, 1857, pp. 452-455.

Beitrage zur Flora der oberen Kreide Quedlinburgs und seiner Umgebung, I. Allgemeine Bemerkungen über das Kreidegebirge zu Blankenburg und in der Grafschaft Wernigerode. Palæont. Bd. v, 1858, pp. 45-70, pl. ix-xi. II. Die Flora des Langebirges bei Quedlinburg. *Ibidem*, Bd. v, 1858, pp. 71-80, pl. xii-xv.

[4] Heer, O., Beiträge zur Kreideflora, II. Kreideflora von Quedlinburg, Neue Denks. Schweiz. Gesell. Naturwiss. Bd. xxiv, 1869, No. 2, pp. 1-15, pl. i-iii.

[5] Schulze, E., Ueber die Flora der subhercynischen Kreide. Zeits. gesammt. Naturwiss., Halle, Bd. lx, 1887, pp. 440-470.

Inaugural Dissertation, Halle, 1888, 33 pp.

[6] Lampe, E., Ueber neue Fundorte der subhercynischen Flora. Zeits. gesammt. Naturwiss., Halle, Bd. lxvii, 1894, pp. 193-198.

[7] Richter, P., Ueber Quedlinburg Kreide-Coniferen. Zeits. deutsch geol. Gesell. Bd. li, Verhandl., pp. 43-44, 1899 (1900).

Beiträge zur Flora der oberen Kreide Quedlinburgs und seiner Umgebung,

The three lower of these were correlated by Schlüter [1] with the Sandkalke von Dulmen (*Scaphites binodosus*), Quarzgesteine von Haltern (*Pecten muricatus*) and Sandmergel von Recklinghausen (*Marsupites ornatus*), respectively. Holzapfel [2] correlated them with the Aachener sands. Kayser (p. 515) states that the Crednerien Quader des Regensteins and the Teufelsmauer bei Neinstedt, as well as the so-called Heimburg and Ilsenberg mergel are of Lower Senonian age (Lower Campanian of de Lapparent). While most authors admit the Campanian age of most of this complex, others correlate the Salzberggestein with the Santonian or upper substage of the Emscherian,[3] which according to de Lapparent also includes the Aachener sands and the Westphalian equivalents, to wit, the marls of Recklingshausen with *Marsupites ornatus* and the sands of

Teil I. Die Gattung Credneria und einige seltenere Pflanzenreste. Leipzig, 1905, 18 pp., 6 pl.

[3] Vater, Heinrich, Die fossilen Hölzer der Phosphoritlager der Herzogthums Braunschweig. Zeits. deutsch geol. Gesell., Bd. xxxvi, 1884, pp. 783-853, pl. xxvii-xxix.

[1] Schlüter, C., Zeits. deutsch. geol. Gesell. Bd. xxviii, 1876, p. 495.

[2] Holzapfel, *Ibidem*, Bd. xxxvii, 1885, p. 605.

[3] Roemer, F. A., Die Versteinerungen des Harzgebirges, Hannover, 1843, 40 pp., 12 pl.

Beyrich, H. E., Ueber die Zusammensetzung und Lagerung der Kreideformation in der Gegend zwischen Halberstadt, Blankenburg und Quedlinburg. Zeits. deutsch. geol. Gesell., Bd. i, 1849, pp. 288-339, 386, 387.

Geinitz, H. B., Das Quadersandsteingebirge oder Kreidebirge im Deutschtion in der Gegend zwischen Halberstadt, Blankenburg und Quedlinburg. Neues Jahrb. 1850, pp. 133-138.

Geinitz, H. B., Das Quadersandsteingebirge oder Kreidegebirge im Deutschland, Freiburg 1849-1850.

Beyrich, H. E., Bemerkungen zu einer geognostischen Karte des nordlichen Harzrandes von Langelsheim bis Blankenburg. Zeits. deutsch. geol. Gesell., Bd. iii, 1851, pp. 567-573, pl. 15 (map).

Ewald, J., Ueber die Kreidesandsteine in den subhercynischen Hügeln der Provinz Sachsen. Bericht. Naturwiss. Verein. Harz. 1855-56, pp. 35-38.

Ewald, J., Geologische Karte der Provinz Sachsen von Magdeburg bis zum Harze. 1:100000, Geognöstische Uebersichtkarte der Provinz Sachsen, 4 Blätter 1865-1869. Berlin, 1864, Blatt. 3: Halberstadt.

Brauns, D., Die senonen Mergel des Salzbergs bei Quedlinburg. Zeits. gesammt Naturwiss. Halle, Bd. xlvi, 1875, pp. 325-420, pl. vii-x.

Frech, F., Die Versteinerungen der unter-senonen Thonlager zwischen Suderode und Quedlinburg. Zeits. deutsch. geol. Gesell., Bd. xxxix, 1887, pp. 141-202, pl. xi-xix.

Haltern with *Pecten muricatus* and *Inoceramus crispi.* The practical synchroneity of the Aachen, Quedlinburg and Westphalian beds mentioned above holds good and it makes but slight difference in the present discussion whether they are considered upper Emscherian or Lower Campanian.

Abietites glückii Richter
Araucarioxylon cf. *keuperianum* Unger (possibly remarked from Triassic)
Araucarites reichenbachi Geinitz
Asplenium cf. *scrobiculatum* Heer
Cf. *Carolopteris aquensis* Debey and Ettingshausen
Carpinoxylon compactum Vater
Cedroxylon cf. *aquisgranense* Gœppert
Ceratostrobus sp.
Chondrophyllum cf. *grandidentatum* Unger
Chrondophyllum hederæforme Heer
Chrondrophyllum tricuspe Schulze *nomen nudum*
Cormoxylon cf. *erraticum* Conwentz.
Cormoxylon myricæforme Vater
Credneria acerifolia Richter
Credneria acuminata Hampe
Credneria arcuata Richter
Credneria atava Richter
Credneria denticulata Zenker
Credneria elongata Richter
Credneria engelhardti Richter
Credneria glandulosa Richter
Credneria integerrima Zenker
Credneria oblonga Schimper
Credneria peltata Richter
Credneria posthuma Richter
Credneria subserrata Hampe
Credneria subtriloba Zenker
Credneria triacuminata Hampe
Credneria zenkeri var. *asymmetrica* Richter
Credneria zenkeri var. *intermedia* Richter
Credneria zenkeri var. *orbicularis* Richter
Credneria zenkeri var. *triloba* Richter
Cunninghamites elegans Corda
Cunninghamites oxycedrus Presl
Cunninghamites squamosus Heer[1]
Cupressinoxylon sequoianum Merckel
Cylindrites spongioides Gœppert
Cyparissidium gracile Heer

[1] This is the *Eurysacis* gen. nov. of Schulze.

Cystisus cretaceus Dunker
Daphnophyllum fraasii Heer
Delessertites cf. *thierensi* Miquel
Dewalquea haldemiana Saporta and Marion
Cf. *Dewalquea insignis* Hosius and von der Marck
Dewalquea nilssoniana Brongniart
Dryandroides haldemiana Hosius and von der Marck
Dryandroides quercinea Velenovsky
Dryophyllum cf. *cretaceum* Debey
Dryophyllum cf. *cuspidigerum* Heer
Dryophyllum cf. *saportæ* Watelet
Dryophyllum cf. *tenuifolium* Debey
Dryophyllum cf. *vittatum* Saporta and Marion
Equisetum zeilleri Richter
Fegonium dryandræforme Vater
Fegonium schenki Vater
Geinitzia cretacea Schimper [1]
Geinitzia formosa Heer [2]
Geinitzia microcarpa Richter
Gleichenia acutiloba Heer
Gleichenia zippei (Corda) Heer
Juglandinium longiradiatum Vater
Juglandinium sp. Vater
Laurinium brunswicense Vater
Liriodendron schwarzii Richter
Lygodites cf. *anemiifolius* Debey and Ettingshausen
Lygodites spatulatus Schulze *nomen nudum*
Myrica cretacea Heer
Myrica cf. *liophylla* Hosius and von der Marck
Myrica schenkiana Heer
Myrica cf. *serrata* Velenovsky
Palmoxylon parvifasciculosum Vater
Palmoxylon radiatum Vater
Palmoxylon scleroticum Vater
Palmoxylon variabile Vater
Paracallipteris potoniei Richter
Paracrednera fritschii Richter
Parathinnfeldia dubia Richter
Pecopteris calopteris Debey and Ettingshausen
Pecopteris cuspidata Schulze *nomen nudum*
Pecopteris osmundacea Schulze *nomen nudum*
Phyllites sp. Schulze
Phyllocladites crenatus Schulze *nomen nudum*
Phyllocladus laciniosa Schulze

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[1] This is the *Ceratostrobus strictus* of Schulze.

[2] *Ceratostrobus formosus* Schulze.

Pityoxylon cretaceum Vater
Plataninium subaffine Vater
Cf. *Podozamites latipennis* Heer
Quercus robusta Schultz *nomen nudum*
Quercus westfalica Hosius and von der Marck
Rhizocaulon najadinum Vater
Rhus cretacea Heer
Salicites hartigi Dunker
Salix fragiliformis Zenker
Salix gœtziana Heer
Scleropteris callosa Brauns
Sequoia concinna Heer
Sequoia gœpperti Dunker
Sequoia intermedia Richter
Sequoia pectinata Heer
Sequoia cf. *pectinata* Heer
Sequoia reichenbachi Heer
Sequoia sp. Brauns
Sycophyllum dentatum Schulze *nomen nudum*
Tœnioxylon varians Felix
Tœnioxylon sp. Vater
Thuites cf. *pfaffii* Heer
Torreya cf. *dicksoniana* Heer
Triphyllum geinitzianum Gœppert
Triphyllum sp. cf. *bignonia silesiaca* Velenovsky
Zamiopsis brevipennis Richter

NIEDERSHŒNA.—One of the most celebrated localities for Upper Cretaceous plants is at Niederschœna (Nieder Schöna) between Dresden and Freiberg and about 7 kilometers northeast of the latter place. Numerous sandstone quarries along the low escarpment that makes the eastern wall of the shallow valley in which the little town of Niederschœna is situated have been worked for generations for local uses and have furnished the fossil plants that have made the town famous in paleobotanical annals. The Upper Cretaceous deposits lie in a shallow depression in a biotite gneiss and comprise a glauconite lower *Pläner* sandstone at the base, overlain by the lower *Quader* sandstone with lenses of carboniferous shales, the sandstone and especially the argillaceous lenses carrying fossil plants. This member is overlain by non-fossiliferous lower *Quader* sands and gravel.

That these lower Cenomanian beds contained fossil plants has been known for upwards of a century, Cotta [1] having described the beds as early as 1836. Six species were recorded from this locality by Sternberg in his "Flora der Vorwelt," and it is mentioned by Brongniart, Zenker, Unger,[2] Gœppert, Bronn, Geinitz [3] and others. Geinitz and Gutbier [4] enumerated nine species of plants in 1843. It remained for Ettingshausen [5] to do justice to this flora in his little monograph published in 1867 in which forty-two species are enumerated. In 1885 Englehardt [6] discussed the forms of Credneria from Niederschœna and in 1891 he made a considerable addition to the flora.[7] Combining the identifications of the above-mentioned authors furnishes the following list of species:

Acer antiquum Ettingshausen
Apocynophyllum cretaceum Ettingshausen
Aralia coriacea Velenovsky
Artocarpidium cretaceum Ettingshausen
Aspidium reichianum Sternberg
Asplenium fœrsteri Debey and Ettingshausen
Banksia longifolia Ettingshausen [8]
Banksia prototypus Ettingshausen
Callistemophyllum heerii Ettingshausen
Carpolithus cretaceus Ettingshausen
Cassia angusta Heer
Cassia ettingshauseni Heer
Caulinites stigmarioides Ettingshausen
Celastrophyllum integrifolium Ettingshausen

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[1] Cotta, Ueber die Niederschöna-Schichten. Neues Jahrb., 1836, pp. 584-588.
Cotta, Georg. Beschreibung der Gegend von Tharand, Dresden und Leipzig, 1836, pp. 54, 57, 58, 125.
Cotta, Ueber die Pflanzenabdrücke aus dem unteren Quadersandstein von Niederschöna bei Freiberg, Isis, von Oken, 1837, col. 442, 443.

[2] Unger, Botanisches Zeitung, 7th Jahrg. 1849, col. 348, 349.

[3] Geinitz, Characteristik der Schichten und Petrefacten des Sachsischen Kreidegebirges, Heft 3, 1842, xxv + 116 pp., 24 pl.

[4] Geinitz and Gutbier, in Gæa von Sachsen, 1843, pp. 133, 134.

[5] Ettingshausen, Die Kreideflora von Niederschœna in Sachsen. Sitz. k. Akad. Wiss. Wien, Bd. lv, Ab. i, 1867, pp. 235-264, pl. i-iii.

[6] Engelhardt, Die Crednerien im unteren Quader Sachsens. Festschrift Isis, 1885, pp. 55-62, 1 pl.

[7] Engelhardt, Ueber Kreidepflanzen von Niederschöna. Gesell. Isis, Ab. vii, 1891, pp. 79-105, pl. ii.

[8] This is confused with the Tertiary form, with which it is not identical.

Celastrophyllum lanceolatum Ettingshausen
Chrysophyllum velenovskyi Engelhardt
Cinnamomum primigenium Ettingshausen
Conospermites hakeæfolius Ettingshausen
Credneria cuneifolia Bronn
Credneria geinitziana Unger
Credneria grandidentata Unger
Culmites cretaceus Ettingshausen
Cunninghamites elegans (Corda) Endlicher
Cunninghamites oxycedrus Sternberg
Cunninghamites sternbergii Ettingshausen
Daphnites gœpperti Ettingshausen
Diospyros primæva Heer
Diospyros provecta Velenovsky
Eucalyptus angusta Velenovsky
Eucalyptus geinitzi Heer
Ficus bumelioides Ettingshausen
Ficus geinitzii Ettingshausen
Ficus prisca Ettingshausen
Ficus protogæa Ettingshausen
Ficus reticulata (Lesquereux) Knowlton ?
Gleichenia comptoniæfolia (Debey and Ettingshausen) Heer
Gleichenia crenata Velenovsky
Gleichenia gracilis Heer
Gleichenia kurriana Heer
Gleichenia zippei Heer
Hymenophyllum cretaceum Lesquereux ?
Inga cottai Ettingshausen
Laurus cretacea Ettingshausen
Leguminosites cretaceus Engelhardt
Liriodendron meekii Heer ?[1]
Lomatites palæo-ilex Ettingshausen
Lygodium cretaceum Debey and Ettingshausen
Microzamia gibba (Reuss) Corda
Mimusops ballotæoides Engelhardt
Myrica fragiliformis (Zenker) Engelhardt
Pecopteris bohemica Corda
Pecopteris geinitzi Dunker
Pecopteris lobifolia Corda
Pecopteris murchisoni Dunker
Pecopteris striata Sternberg
Phacidium myrtophylli Engelhart
Phacidium palæocassiæ Ettingshausen
Phyllites reichi (Sternberg) Rothpletz[2]

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[1] Probably a leguminous leaf and not identical with *L. meekii.*
[2] This is the well-known *Halyserites reichii* of Sternberg.

Pinus quenstedti Heer
Pisonia atavia Velenovsky
Protea haidingeri Ettingshausen
Pteris frigida Heer
Pteris reichiana Ettingshausen
Pterophyllum cretosum Reich
Pterophyllum reichianum Engelhardt
Pterophyllum saxonicum Reich
Quercus beyrichii Ettingshausen
Rhamnus tenax Lesquereux
Rhopala primæva Ettingshausen
Salix schœnæ Engelhardt
Sapindus saxonicus Engelhardt
Sapotacites stelzneri Engelhardt
Sequoia heterophylla Velenovsky
Sequoia minor Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Simaba ? saxonica Engelhardt
Sphenopteris mantelli Brongniart[1]
Sterculia geinitzi Engelhardt
Triplaris cenomanica Engelhardt
Widdringtonites reichii (Ettingshausen) Heer
Xylómites ellipticus Ettingshausen

This list totals 81 species, of which 3 are referred to the Fungi, 16 to the Ferns, 3 to the Cycads, 8 to the Conifers, 2 to the Monocotyledons and 48 to the Dicotyledons. Thirty-five species are peculiar to this locality. Of those having an outside distribution, 21 occur in the contemporaneous Perucer schichten south of the Erzgebirge in Bohemia, and several additional occur in the continuation of these beds in Moravia, 13 are found in the Atane beds of Greenland and 6 in the Patoot beds of that country, 5 are found in the Turonian of Europe, 6 in the Emscherian and 6 in the Aturian. These include wide ranging forms, like *Cunninghamites elegans, Sequoia reichenbachi* and *Eucalyptus geinitzi.*

A relatively large number of these Saxon forms have been identified from the North American Upper Cretaceous. Thus there are 11 of these species recorded from the Dakota sandstone, 8 from the Raritan formation and 9 from the Magothy formation of the Middle Atlantic Slope, while others are represented in the Upper Cretaceous floras of the south Atlantic and Gulf Coastal Plain.

[1] This is now referred to *Onychiopsis psilotoides* (Stokes and Webb) Ward. The determination of the Saxon remains by Engelhardt is probably erroneous.

DRESDEN.—The only other important Upper Cretaceous plant beds in the Kingdom of Saxony are those from the *Quader* in the vicinity of Dresden and Dippoldiswalde first studied by Glocker and elaborately (but poorly) described by von Otto[1] about the middle of the last century. The flora consists, for the most part, of poorly preserved and indefinite remains. It is younger than that at Niederschœna and probably corresponds to the middle horizon of the Cenomanian or the zone of *Ostrea carinata* of the recent sections by Petraschek. Following is a list of Otto's determinations:

Arundinites wohlfarthi Otto
Asterosoma radiciforme Otto
Carpolites
Credneria
Chondrites fursillatus Rœmer
Cunninghamites mantelli Geinitz
Cunninghamites oxycedrus Presl
Cupressinea insignis Geinitz
Cylindrites spongioides Gœppert
Dilleniaceæ
Geinitzia cretacea Endlicher
Halyserites reichi Sternberg
Keckia annulata Glocker
Keckia cylindrica Otto
Keckia nodulosa Otto
Keckia vesiculosa Otto
Palmacites varians Corda
Pinus exogyra Corda
Proteaceæ
Pterophyllum cretosum Reich
Pterophyllum germari Otto
Sphærococcites striolatus Presl
Spongia ottoi Geinitz
Spongia saxonica Geinitz
Zamiostrobus

This list could be considerably extended by searching through the works of H. B. Geinitz who was such a voluminous writer on the German Upper Cretaceous and who followed Rœmer in describing so many trails, current markings, and similar objects in the *Quader* as fossil plants. It

[1] Otto, Ernst von, Additamente zur Flora des Quadergebirges in der Gegend um Dresden und Dippoldiswalde. pt. I, 1852, 29 pp., 7 pls.; pt. II, 1854, 53 pp., 9 pls.

would serve no useful purpose to unduly swell the lists in this chapter with these indefinite forms.

Westphalia

A considerable flora has been recorded from the Upper Cretaceous of Westphalia. Rœmer in his Cretaceous of North Germany (1840) described one species (*Chondrites furcillatus*) from the *Pläner* of Rothenfelde. In 1863 von der Marck[1] described eleven species from the *Plattenkalk* at Drensteinfurth, Albersloh and Arenfeld near Sendenhorst. In 1867 Saporta[2] published a brief paper in which he recorded four species from a new locality—Haldem. In 1869 Hosius introduced into his Geognosy of Westphalia[3] a discussion of a considerable number of fossil plants from Legden, Sendenhorst, Albersloh, etc. The same year appeared his account of the dicotyledons of the Westphalian Cretaceous[4] chiefly from Legden near Coesfeld, and from Sendenhorst. Eleven years later Hosius and von der Marck published their monograph on the Cretaceous floras of Westphalia.[5] All of the previous work is reviewed and brought up to date. Five years later (1885) they published a short supplement.[6]

They follow Schlüter's nomenclature[7] in the division of the Cretaceous and enumerate a number of new localities, *e. g.*, Baumberge, Höpingen,

[1] Von der Marck, W., Fossile Fische, Krebse und Pflanzen aus dem Plattenkalk der jüngsten Kreide in Westphalen. Palæont. Bd. xi, 1863, pp. 1-82, pl. 1-14.

[2] Saporta, G. de, Note sur une collection de plantes fossiles prevenant de la craie à Belemnites mucronatus de Haldem en Westphalie. Bull. Soc. géol. France, 2é ser., tome xxiv, 1867, pp. 33-36.

[3] Hosius, A., Die in der Westfälischen Kreideformation vorkommenden Pflanzenreste. Münster, 1869, pp. 1-34.

[4] Hosius, A., Ueber einige Dicotyledonen der Westfälischen Kriedeformation. Palæont., Bd. xvii, 1869, pp. 89-104, pl. 12-17.

[5] Hosius und von der Marck, Die Flora der Westfälischen Kreideformation. Palæont. Bd. xxvi, 1880, pp. 125-236, pl. 24-44.

[6] ——— Weitere Beiträge zur Kenntniss der fossilen Pflanzen und Fische, etc. Nachtrag zur Flora der Westfälischen Kreideformation. Palæont. Bd. xxxi, 1885, pp. 225-232, pl. 19-20.

[7] Schlüter, C., Verbreitung der Cephalopoden in der oberen Kreide Norddeutschlands. Zeits. deutsch. geol. Gesell. Bd. xxviii, 1876, pp. 457-518.

Bracht, Stormberg, Oelde, Dolberg, Rinkhove, Darup, Chaussee, Lemförde, etc.

The Turonian of Tecklenberg, Rothenfelde, etc., is credited with *Araucaria* sp., *Chondrites furcillatus* Rœmer, and *Cupressinoxylon turoniense* Hosius and Von der Marck.

The following species are recorded from the Campanian of Legden, Steinfurt, Dulmen, etc.:

Artocarpus undulata Hosius
Chondrites intricatus Sternberg
Conferites aquensis Debey and Ettingshausen
Credneria denticulata Zenker
Credneria integerrima Zenker
Credneria subtriloba Zenker
Credneria tenuinervis Hosius
Credneria triacuminata Hampe
Credneria westfalica Hosius
Cunnninghamites squamosus densifolius von der Marck
Cunninghamites recurvatus Hosius and von der Marck
Cunninghamites squamosus Heer
Cunninghamites squamosus densifolius von der Marck
Cycadoxylum westfalicum Hosius and von der Marck
Cylindrites conicus Hosius and von der Marck
Delessertites thierensi Bosquet
Eolirion primigenium Schenk ?
Ficus crassinervis Hosius
Ficus cretacea Hosius
Ficus dentata Hosius
Ficus elongata Hosius
Ficus gracilis Hosius
Ficus longifolia Hosius
Ficus reuschii Hosius
Ficus tenuifolia Hosius
Limnophyllum lanceolatum Hosius and von der Marck
Limnophyllum primævum Hosius and von der Marck
Litsæa laurinoides Hosius and von der Marck
Melastomites cuneiformis Hosius and von der Marck
Pistites loriformis Hosius and von der Marck
Quercus cuneata Hosius
Quercus latissima Hosius
Quercus legdensis Hosius
Quercus longifolia Hosius
Quercus paucinervis Hosius
Quercus wilmsii Hosius
Sequoia legdensis Hosius and von der Marck

Sequoia reichenbachi (Geinitz) Heer
Taxoxylum haternianum Hosius and von der Marck
Tempskya cretacea Hosius and von der Marck
Thalassocharis westfalica Hosius and von der Marck
Viburnum subrepandum Hosius and von der Marck

The Maestrichtian flora (*Cœloptychien Kreide*) is recorded from a large number of localities in the Münster basin, some of which may have already been mentioned. These are not all of the same age, the schichten, mergel and sandsteine der Baumberge and the Hügelgruppe von Haldem-Lemförde being younger than the plattenkalk von Sendenhorst, the latter being said to be the youngest Cretaceous in the basin. By combining the fossil plants that have been recorded from all of these localities the following list is obtained:

Apocynophyllum cuneatum Hosius and von der Marck
Apocynophyllum subrepandum von der Marck
Aralia denticulata Hosius and von der Marck
Cf. *Ceanothus* sp.
Chondrites furcillatus latior von der Marck
Chondrites intricatus Sternberg
Chondrites fungiformis Debey and Ettingshausen
Chondrites polymorphus Hosius and von der Marck
Chondrites subcurvatus Hosius and von der Marck
Comptonia tenera Hosius and von der Marck
Cunninghamites elegans (Corda) Endlicher
Cunninghamites squamosus Heer
Dewalquea gelindensis Saporta and Marion
Dewalquea haldemiana Saporta and Marion
Dewalquea haldemiana angustifolia Hosius and von der Marck
Dewalquea haldemiana latifolia Hosius and von der Marck
Dewalquea insignis Hosius and von der Marck
Dryandroides haldemiana Hosius and von der Marck
Dryandroides macrophylla Hosius and von der Marck
Eolirion ? nervosum Hosius and von der Marck
Eolirion primigenum Schenk ?
Eolirion ? subfalcatum Hosius and von der Marck
Eucalyptus haldemiana Debey
Eucalyptus inæquilatera von der Marck
Ficus angulata Hosius and von der Marck
Ficus densinervis Hosius and von der Marck
Ficus laurifolia Hosius and von der Marck
Frenelopsis königii Hosius and von der Marck (*Calamitopsis königi* von der Marck)
Haliserites contortuplicatus von der Marck

Laurus affinis Hosius and von der Marck
Myrica leiophylla Hosius and von der Marck
Myrica primæva
Cf. *Myrtophyllum cryptoneuron* Saporta and Marion
Nerium röhlii von der Marck
Cf. *Oreodaphne apicifolia* Saporta and Marion
Osmunda haldemiana Hosius and von der Marck
Pinus monasteriensis Hosius and von der Marck
Populus tremulæformis Hosius and von der Marck
Posidonia cretacea Hosius and von der Marck (*belonodendron densifolium* von der Marck)
Quercus asymetra Hosius and von der Marck
Quercus castanoides Hosius and von der Marck
Quercus dryandræfolia von der Marck
Quercus euryphylla Hosius and von der Marck
Quercus formosa Hosius and von der Marck
Quercus hieraciifolia Hosius and von der Marck
Quercus iliciformis Hosius and von der Marck
Quercus rhomboidalis Hosius and von der Marck
Quercus sphenobasis Hosius and von der Marck
Quercus westfalica latior Hosius and von der Marck
Quercus westfalica oblongata Hosius and von der Marck
Quercus westfalica obtusata Hosius and von der Marck
Cf. *Rhamnus* sp.
Sequoia reichenbachi (Geinitz) Heer (*Araucarites appressus* von der Marck)
Tænidium alysioides Hosius and von der Marck
Tetraphyllum dubium Hosius and von der Marck
Thalassocharis westfalica Hosius and von der Marck

The Saxon-Bohemian area, somewhat fully treated in considering the fossil plants of the latter country (*Chlomeker schichten*), need not be mentioned under Germany except to call attention to two early papers by Gœppert[1] describing what is for the most part entirely worthless material from beds in Silesia of Emscherian age.

The forms enumerated are the following:

Carpinites arenaceus Gœppert
Cylindrites spongiodes Gœppert
Dammarites crassipes Gœppert
Flabellaria chamæropifolia Gœppert
Muensteria schneideriana Gœppert
Phyllites acuminatus Gœppert

[1] Gœppert, H. R., Ueber die fossile Flora des Quadersandsteins von Schlesien. Nova Acta, Bd. xix, 1842, pp. 97-134, pls. xlvi-liii. Nachtrag *Ibid.*, Bd. xxii, 1848, pp. 353-365, pls. xxxv-xxxviii.

Phyllites emarginatus Gœppert
Phyllites enervis Gœppert
Phyllites geinitzianus Gœppert
Phyllites testaceus Gœppert
Protopteris singeri Presl
Salicites petzeldianus Gœppert

AUSTRIA-HUNGARY

The dual monarchy is celebrated in the annals of paleobotany, not only as the home of Sternberg, Corda, Unger, and Ettingshausen, but also for its profusion of Tertiary floras. None of its subordinate political divisions are especially rich in Upper Cretaceous plants except the old kingdom of Bohemia, the northern part of which is underlain by the widely distributed formations of the Upper Cretaceous, which extend northward and westward into Saxony, and northward and eastward into Silesia and Moravia. It will therefore be most useful to consider first the important Bohemian section, after which the less important floras of Moravia, Dalmatia, the Tyrol, Austria, and Hungary may be briefly considered in the order indicated.

Bohemia

The Bohemian section is of the greatest importance for the paleobotanist because of the large flora that has been thoroughly described from its various horizons and the certainty with which these floras have been correlated with the contemporaneous faunas. It is of especial interest to the American student because of the parallelism between the Cretaceous history of the Bohemian basin and that of the Atlantic Coastal Plain, and this parallelism extends even to the character of the deposits as well as to the similarities of the contemporaneous floras and faunas. Among the students of Bohemian Cretaceous Geology, the names of Reuss, Geinitz, Schlœnbach, Krejčí, Frič (Fritsch), Jahn, Zahálka, Petrascheck, Woldřich and Scupin may be mentioned. The results down to 1903 are admirably summarized in the last edition of Katzer's "Geologie von Böhmen," Prague, 1903.

The earliest publication dealing with the Bohemian Cretaceous plants is the monumental work of Sternberg,[1] to which both Presl and Corda[2] made valuable contributions. Several plants from this area, including *Dammarites albens, Thuites alienus, Thuites gramineus, Caulerpites fastigiatus, Steinhauera minuta, Protopteris punctata*, etc., are described and figured, and both the Cenomanian and Turonian stages are represented.

Corda, another native of Bohemia, was not only an eminent histologist but an earnest student of fossil as well as recent plants, and had not his life terminated at the early age of 39 in the tragic sinking of the Bremen steamer "Victoria" in mid-Atlantic in 1849, he would unquestionably rank as one of the more eminent students of fossil plants. His work for Sternberg paved the way for his two other principal works, "Beiträge zur Flora der Vorwelt," Prague, 1855, and "Die fossilen Pflanzen der böhmischen Kreide-formation." The first of these works deals mainly with Carboniferous plants, but contains careful descriptions and illustrations of *Protopteris, Tempskya* and *Krannera* from the Bohemian Cretaceous. The second forms a part of Reuss's "Versteinerungen der böhmischen Kreideformation," Stuttgart, 1846, and contains descriptions and figures of a considerable number of plants from both the so-called Pläner and Quader of Bohemia.

The abundant flora contained in the beds of Perutz, the so-called Perucer Schichten was discussed in several short papers by Krejčí,[3] Reňger,[4] Feistmantel,[5] Stur,[6] Frič,[7] and Rodr.[8] In 1869 in the first volume

[1] Sternberg, Versuch einer geognostische-botanischen Darstellung der Flora der Vorwelt. Published in parts from 1820-1838 and translated into French by the Compte de Bray.

[2] Corda, A. C. J., Skizzen zur vergleichenden Phytotomie vor-und-jetztweltlicher Pflanzen, 1838. Appendix to Heft 8 of Sternberg's work.

[3] Krejčí, Johann, Kounická skála (Kounicer Steinbruch), Žeits. Ziva, Jahrg. 1, 1853.

Krejči, J., Ueber ein neues Vorkommen des Bernsteins in der böhmischen Kreideformation. Sitz. k. böhm. Gesell. Wiss., Prag, 1875, p. 148.

[4] Reňger, Karl, Predvéké rostlinstvo krídového útvaru českého (Die vorweltliche Flora der böhmischen Kreideformation), *Ibidem*, Jahrg. xiii, 1866.

Reňger, Karl, Stromovité kapradiny Kridovém útvaru českém (Die Baumfarne in der Kreideformation Böhmens), *Ibidem*.

of the "Archiv. naturw. Landesdurchforschung von Böhmen," Professor Anton Frič commenced the publication of his monumental studies of the Bohemian Cretaceous (Studien im Gebiete der böhmischen Kreide formation-Paleontologische untersuchungen der einzelnen schichten in der böhmischen Kreideformation) during the progress of which he has been assisted in the study of the fossil plants first by Feistmantel, then by Velenovsky, and in later years by Bayer. The first of these studies, published in 1869,[1] is devoted to the structure, lithology, areal distribution, and flora and fauna of the Perucer beds. The second published in 1877[2] treats of the Weissenberger and Malnitzer beds.

With the exception of Frič's work just mentioned and the three species described by Saporta[3] from the Perucer beds, nothing beyond the frequent mention of Cretaceous plants from Bohemia in general works appears until the year 1881 when Velenovsky[4] in a preliminary paper announced his extensive studies on the flora, which commenced to appear the next year. His discussion of the dicotyledonous plants came out in four parts in Band ii (1882), iii (1883), iv (1884), v (1885), of the "Beiträge zur Paläontologie Oesterreichungarns und des Orients," von Mojesisovics und Neumayr, under the title of "Die Flora der böhmischen

[5] Feistmantel, O., Ueber die Reste der Kreideformation bei Kuchelbad. Sitz. k. böhm. Gesell. Wiss., Prag, 1870, pp. 73-75.

Feistmantel, O., Ueber Baumfarnenreste der böhmischen Steinkohlen-, Perm-, und Kreideformation. Abh. k. böhm. Gesell. Wiss., Prag, 1872, vi Folge, v Band.

Feistmantel, O., Vorbericht über die Perucer Kreideschichten in Böhmen und ihre fossilen Reste. Sitz. k. böhm. Gesell. Wiss., Prag, 1874, pp. 255-276.

[6] Stur, D., Vorkommen einer Palmenfrucht Hülle, *Lepidocaryopsis westphaleni*, n. g. et sp. in Kreide-sandstein der Peruzer-schichten bei Kamnitz in Böhmen. Verhandl. k. k. geol. Reichs., Wien, 1873, pp. 1-3.

[7] Frič, A., Ueber fossile Baumstämme in der Umgebung von Wittingen und Frauenberg. Sitz. k. böhm. Gesell. Wiss., Prag, 1873, pp. 109-111.

[8] Rodr, E., O nékterych kmenech z českého útvaru kridového. (Ueber einige Stämme aus der böhmischen Kreideformation.) Vesmir, Jahrg. vii, 1878.

[1] Band i, Theil 2, Prag, 1869.

[2] Band iv, Nr. 1, Prag, 1877, pp. 1-152, tf. 1-154.

[3] Saporta, Le Monde des Plantes, Paris, 1879, pp. 199, 200, tf. 28, 29.

[4] Velenovsy, Vorläufiger Bericht über die dicotyledonen Pflanzen der böhmischen Kreideformation. Sitz k. böhm. Gesell. Wiss., Prag, 1881, pp. 212-219.

Kreideformation." His description of the gymnospermous plants was published as a separate work in 1885 through a subvention from the committee for the investigation of the natural history of Bohemia and constitutes a handsome folio volume of 34 pages and 13 plates. Several shorter subsequent papers[1] complete the enumeration of Velenovsky's contributions to the elucidation of these floras. They are most important and comprehensive, and the discussions are fuller and the figures better than those in the later work of Frič and Bayer. Meanwhile Frič had published his third volume of studies devoted to the Iserschichten,[2] and his fourth volume devoted to the Teplitzer schichten.[3] In 1892 Englehardt contributed a short paper on the Cretaceous plants in the collection of the Geological Institute of the University at Prague,[4] and the next year Frič published his fifth volume devoted to the Priesener schichten.[5]

Velenovsky, who had collaborated with Frič, becoming more and more engrossed in the study of the recent botany, his work on fossil plants was taken up by Edvin Bayer of the Bohemian National Museum, who made his contribution in this field of study in 1896.[6] This was the basis for the paleobotanical part of Frič's sixth volume of studies which treated of

[1] Velenovsky, Neue Beiträge zur Kenntniss der Pflanzen des Böhmischen Cenomans, Sitz k.. böhm Gesell. Wiss., Prag, 1886 (1887), pp. 633-645, 1 pl.

Velenovsky, Uber einige neue Pflanzenformen der böhmischen Kreideformation. *Ibidem*, 1888.

Velenovsky, Die Farne der böhmischen Kreideformation, Abhandl. k. böhm. Gesell. Wiss. 7 folge, Bd. 2, 1888, pp. 1-32, pl. 1-6.

Velenovsky, Kvétena českého cenomanu, Rozpravy Králčeské Společnoski nank., Bd. vii, 1889, pp. 1-75, pl. 1-6.

[2] Frič, Anton, Studien etc., iii. Die Iserschichten. Archiv. Naturw. Landesd. Böhmen, Bd. v, Nr. 2, 1883, pp. 1-137, tf. 1-132 (only figs. 129-132 devoted to fossil plants).

[3] Frič, Anton, Studien etc., iv. Die Teplitzer Schichten. *Ibidem*, Bd. vii, Nr. 2, 1889, pp. 1-119, tf. 1-167 (only figs. 166-167 devoted to fossil plants).

[4] Engelhardt, H., Ueber böhmische Kreidepflanzen. Mitt. aus dem Osterlande, Neue folge, Bd. v, Altenburg, 1892.

[5] Frič, Anton, Studien etc., v. Priesener Schichten. *Op. cit.*, Bd. ix, Nr. 1, 1893, pp. 1-134, tf. 1-194 (figures 177-194 devoted to fossil plants).

[6] Bayer, Edvin, O rostlinstvu vrstev chlomeckych. (Ueber die flora der Chlomeker Schichten). Sitz. k. böhm. Gesell. Wiss., Prag, 1896, pp. 1-36, tf. 1-22.

the Chlomeker schichten.[1] Bayer published a second paper in 1899 on new plants from the Perucer beds,[2] and collaborated with Frič in the publication of his seventh volume of studies published[3] in 1901 and containing a critical revision of the well preserved and abundant flora of the Perucer beds. The same year Marik[4] published a brief paper in Bohemian in which several poorly characterized additions are made to the Perucer flora, and more recently Menzel has included some Cretaceous material in his paper on the Conifers from the Cretaceous and Brown Coal of northern Bohemia.[5] According to the latest interpretation[6] the Bohemian section includes all of the Upper Cretaceous from the older Cenomanian upward into the Emscherian.

CENOMANIAN.—The Cenomanian is subdivided into older Cenomanian or lower Quader, comprising the Perucer and Korytzaner Schichten and a younger comprising the Pläner, Pläner sandstone and Glauconitic sandstone or zone of *Actinocamax plenus*. The oldest of these beds, the Perucer series, corresponds to the plant beds of Moletein and Kunstadt in Moravia and to the Credneria stage at the base of the Saxon Upper Cretaceous.

For the paleobotanist the Perucer beds are the most interesting, since from them one hundred and seventy-seven species of fossil plants have been described by the authors previously cited. The Perucer beds were named by Frič in 1869, who enumerated twenty-two species of fossil plants from them at that early date. The description of the bulk of the Perucer flora is due to Velenovsky and his "Kvétena ceského cenomanu,"

[1] Frič, Anton, Studien etc., vi. Die Chlomeker schichten. Archiv. Naturw. Landesd. böhm, Bd. x, Nr. 4, 1897, pp. 1-83, tf. 1-125.

[2] Bayer, E., Einige neue Pflanzen der Perucer Kreideschichten in Böhmen. Sitz. k. böhm. Gesell. Wiss., Prag, 1899, pp. 1-51, tf. 1-15, pl. 1, 2.

[3] Frič and Bayer, Studien etc., Perucer Schichten. *Op. cit.*, Bd. xi, No. 2, 1901, pp. 1-180, tf. 1-133 (plants) + 1-33 (animals).

[4] Marik, V., Prispevek k. flore ceského cenomann. Rozpr. Cesk. Akad. Cis. Frant. Jos. x, tr. 2, c. 3, 16 pp., 2 pl., 1901.

[5] Menzel, P., Fossile Koniferen aus der Kreide und Braunkohlenformation Nordböhmens. Isis, Jahrg. 1908, heft. 2, pp. 27-32, pl. ii.

[6] Scupin, H., Neues Jahrb. Beilage-Band, 24, 1907, pp. 676-714.

Hibsch and Seeman, Blatt Leitmeritz-Triebsch, Tschermak's Min. und Pet. Mitt. neue folge, Bd. 32, 1 and 2 Heft, 1913, pp. 1-128.

published in 1889, was the main basis for Frič and Bayer's subsequent contributions to this flora. The Perucer beds consist of a basal conglomerate developed locally, above which are coarse and fine sandstones, and dark micaceous clays with lenses of lignite. They are strikingly like the Raritan and Magothy formations of the Atlantic Coastal Plain or the Tuscaloosa formation of the Eastern Gulf area, and as in the case of the American beds, the lignites contain pellets of amber. The Perucer beds in different parts of the Bohemian basin overlie the ancient crystalline rocks and the strata of Silurian, Carboniferous or Permian. They are regarded by Frič and Bayer as fresh water deposits and by Woldrich[1] as of marine origin, although they contain no marine fossils as far as is known. Like the American formations mentioned above they are probably partly of continental origin and in part represent the initial deposits of the shallow eastern portion of the north European Cretaceous sea. The latest work by Frič and Bayer enumerates, in addition to the plants, 2 vertebrates, 3 fresh-water mollusca, 22 insects (mostly obscure tracks, galls, etc.), and 2 doubtful forms. The plants come from over 40 localities, of which the best known and most prolific are Hloubtein, Vyserovic, Kounic, Melník, Landsberg, Bohdánkov, Lipenec, Peruc, Mseno, Lidic, Otruby, Vydovle and Kuchelbad. They include the following species:

Abies chuchlensis Velenovsky
Acrostichum cretaceum Velenovsky
Acrostichum tristaniæphyllum Bayer
Aralia anisoloba Velenovsky
Aralia daphnophyllum Velenovsky
Aralia decurrens Velenovsky
Aralia (Panax) dentifera Velenovsky
Aralia formosa Heer
Aralia furcata Velenovsky
Aralia kowalewskiana Saporta
Aralia minor Velenovsky
Aralia propinqua Velenovsky
Aralia transitiva Velenovsky
Aralia triloba Velenovsky
Araucaria bohemica Velenovsky
Aristolochia tecomæcarpa Bayer

[1] Woldrich, Sitz. k. böhm. Gesell. Wiss., Prag, 1899, p. 26.

Asplenium fœrsteri Debey and Ettingshausen
Asplenium velenovskyi Marik
Banksia pusilla Velenovsky
Banksites saportanus Velenovsky
Benthamia dubia Velenovsky
Bignonia cordata Velenovsky
Bignonia pulcherrima Bayer[1]
Bombax argillaceum Velenovsky
Bresciphyllum cretaceum Velenovsky
Butomites cretaceus Velenovsky
Callistemon cretaceum Velenovsky
Callistemophyllum bruderi Engelhardt
Carpolithes vyserovicensis Bayer
Ceratostrobus echinatus Velenovsky
Ceratostrobus sequoiæphyllus Velenovsky
Cercospora coriococcum Bayer
Chamæcyparites charonis Velenovsky
Chamæcyparites sp. Velenovsky
Cissophyllum exulum Velenovsky
Cissus vitifolia Velenovsky
Cocculus cinnamomeus Velenovsky
Conospermites hakeæfolius Ettingshausen
Corticites stigmarioides (Ettingshausen) Engelhardt
Credneria arcuata Velenovsky
Credneria bohemica Velenovsky
Crotonophyllum cretaceum Velenovsky
Cunninghamia stenophylla Velenovsky
Cunninghamites elegans (Corda) Endlicher
Cussonia partita Velenovsky
Cyparissidium minimum Velenovsky
Cyparissidium pulchellum Velenovsky[2]
Dacrydites incertus Marik[3]
Dammara borealis Heer
Dammarophyllum striatum Velenovsky
Dewalquea coriacea Velenovsky
Dewalquea pentaphylla Velenovsky
Diceras cenomanicus Velenovsky
Dicksonia (Protopteris) punctata (Sternberg) Heer
Dioonites cretosus (Reich) Schimper
Diospyros provecta Velenovsky
Dipteriphyllum cretaceum (Velenovsky) Krasser
Dryandra cretacea Velenovsky
Drynaria astrostigmosa Bayer

[1] This is identical with American species of *Liriodendropsis*.
[2] From Korytzaner schichten only.
[3] Probably nothing but a twig of *Sequoia reichenbachi*.

Drynaria dura (Velenovsky) Bayer
Drynaria fascia Bayer
Drynaria tumulosa Bayer
Echinostrobus minor Velenovsky [1]
Echinostrobus squamosus Velenovsky [1]
Ephedrites baccatus Marik
Eucalyptus angusta Velenovsky
Eucalyptus geinitzi Heer
Ficus elongata Velenovsky [2]
Ficus krausiana Heer
Ficus peruni Velenovsky
Ficus stylosa Velenovsky
Ficus suspecta Velenovsky
Folia filicum involuta Frič and Bayer
Frenelopsis bohemica Velenovsky
Gleichenia acutiloba Heer
Gleichenia crenata Velenovsky
Gleichenia delicatula Heer
Gleichenia multinervosa Velenovsky
Gleichenia rotula Heer
Gleichenia vidovlensis Marik
Gleichenia votrubensis Bayer
Gleichenia zippei Heer
Gleichenites coriaceus Marik
Glyptostrobus europæus cretaceus Velenovsky
Grevillea constans Velenovsky
Grevillea dvoraki Bayer
Grevillea tenera Velenovsky *(= Thyrsopteris grevilloides)*
Gymnogramme bohemica Bayer
Hedera credneriæfolia Velenovsky
Hedera primordialis Saporta
Hederæphyllum peltatum Marik
Hymenæa elongata Velenovsky
Hymenæa inæqualis Velenovsky
Hymenæa primigenia Velenovsky
Illicium deletum Velenovsky
Inga latifolia Velenovsky
Inolepis bohemica Marik
Jeanpaulia carinata Velenovsky
Juniperus macilenta Heer
Kirchnera arctica (Heer) Velenovsky
Kirchnera dentata Velenovsky
Krannera mirabilis Corda *(in litt.)*
Laurus affinis Velenovsky

[1] Congeneric with the genus *Brachyphyllum* of American authors.
[2] This is antedated by *Ficus elongata* Hosius and von der Marck, 1869.

Laurus plutonia Heer
Lepidocaruopsis westphaleni Stur
Leptospermum cretaceum Velenovsky
Libocedrus salicornioides cretacea Velenovsky
Litsæa bohemica Engelhardt
Magnolia alternans Heer
Magnolia amplifolia Heer
Magnolia capellinii Heer
Marattia cretacea Velenovsky
Marsilia cretacea Velenovsky
Menispermophyllum celakovskianum Velenovsky[1]
Microdictyon dunkeri (Schenk) Velenovsky
Microlepidium striatulum Velenovsky
Microzamia gibba (Reuss) Corda
Myrica fragiliformis (Zenker) Engelhardt
Myrica serrata Velenovsky
Myricanthium amentaceum Velenovsky
Myricophyllum glandulosum Velenovsky
Myrsinophyllum varians Velenovsky
Nilsonia bohemica Velenovsky
Oncopteris kauniciana (Dormitzer) Velenovsky
Oncopteris nettwalli Dormitzer
Onychiopsis capsulifera (Velenovsky) Nathorst
Osmundophyllum cretaceum Velenovsky
Pecopteris lobifolia Corda
Pecopteris minor Velenovsky
Phacidium circumscriptum Bayer
Phyllites bipartitus Velenovsky (cf. *Bauhinia*)
Picea cretacea Velenovsky
Pinus cretacea Velenovsky
Pinus longissima Velenovsky
Pinus protopicea Velenovsky
Pinus quenstedti Heer
Platanus lævis Velenovsky
Platanus velenovskyana Krasser
Platanus vyserovicensis Marik
Plutonia cretacea Velenovsky
Poacites cretaceus Marik
Podocarpus cretacea Velenovsky
Podocarpus sp. Velenovsky
Podozamites eichwaldi Schimper
Podozamites lanceolatus (L. and H.) Heer
Podozamites latipennis Heer
Podozamites longipennis Velenovsky

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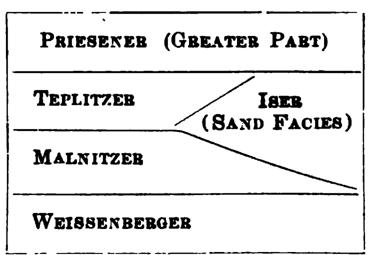
[1] See Berry, Liriodendron Celakovskii Velenovsky. Bull. Torrey Bot. Club, vol. xxix, 1902, pp. 478-480.

Podozamites obtusus Velenovsky
Podozamites pusillus Velenovsky
Polypodites gracilis Marik
Polypodites zonatus Marik
Proteoides acuta Heer
Proteoides reussi Engelhardt
Proteophyllum coriaceum Velenovsky
Proteophyllum cornutum Velenovsky
Proteophyllum decorum Velenovsky
Proteophyllum laminarium Velenovsky
Proteophyllum paucidentatum Velenovsky
Proteophyllum productum Velenovsky
Proteophyllum saportanum Velenovsky
Proteophyllum trifidum Velenovsky
Proteopsis proserpinæ Velenovsky
Pseudoasterophyllites cretaceus (Feistm.) Velenovsky
Pteris albertini Velenovsky *(Cladophlebis albertsii)*
Pteris frigida Heer
Pteris slivenecensis Marik
Puccinites cretaceus Velenovsky
Raphaelia woldrichi Marik
Sagenopteris variabilis Velenovsky
Salix perucensis Velenovsky
Sapindophyllum pelagicum (Unger) Velenovsky
Sapindus apiculatus Velenovsky
Sapotacites obovata Velenovsky
Sassafras acutilobum Lesquereux
Selaginella dichotoma Velenovsky
Sequoia crispa Velenovsky
Sequoia fastigiata (Sternberg) Velenovsky
Sequoia heterophylla Velenovsky
Sequoia major Velenovsky
Sequoia minor Velenovsky
Sequoia oblonga Marik
Sequoia reichenbachi (Geinitz) Heer
Sequoia rigida Heer
Sequoites polyanthes Marik
Sphærococcites laubei Engelhardt
Sphenopteridium tenerium Marik
Sterculia limbata Velenovsky
Tempskya varians (Corda) Velenovsky
Terminalia rectinervis Velenovsky
Ternstrœmia crassipes Velenovsky
Widdringtonites reichii (Ettingshausen) Heer
Zamites bohemicus Velenovsky

These comprise 4 Fungi, 39 Filices, 2 Marsiliaceæ, 1 Selaginella, 1 Equisetacea, 11 Cycadophytes, 3 Araucarieæ, 33 Coniferæ, 2 Monocotyledonæ, and 88 Dicotyledonæ. One hundred and twenty-seven of these are peculiar to the Perucer beds and 37 are confined to the Perucer and to other Cenomanian horizons. Of supposedly older forms three are identified with Wealden (Sequoia, Pteris and Microdictyon) species, two Podozamites are identified with species recorded first in the middle Jurassic. Five species are identified with forms described by Heer from the Kome beds (Barremian) of Greenland. These comprise a Sequoia, a Pteris and three Gleichiniæ. One species (Eucalyptus) has been recorded by Saporta from the Albian of Portugal. Nine of the Perucer forms range upward greater or less distances in the Bohemian Turonian and seven additional range to the top of the Bohemian section (Emscherian). Three additional are found in the Emscherian of other areas. Most of these floral types are represented in American Upper Cretaceous floras, in a few cases even by identical species. Conformably overlying the Perucer beds, but transgressing them and in places resting on Crystallines or Paleozoics are the Korytzaner beds, marine glauconite and fossiliferous sands without plant fossils except for the somewhat doubtful species *Cyparissidium pulchellum* Velenovsky.

TURONIAN.—The Turonian stage is extensively represented in Bohemia by a varied series of deposits with extensive marine faunas and a limited



number of fossil plants. The main stages are shown in the accompanying diagram. The Weissenberger beds were described by Reuss (1845) as the "Pläner Sandstein von Hrádek und Triblitz," and were subsequently long known as the "Pläner des Weissen Berges bei Prag," since they are char-

acteristic and widely distributed in middle Bohemia. Frič (1878) describes four facies, *i. e.:*

(1) Plänerfacies with fossils (vicinity of Prague and Leitmeritz).
(2) Plänerfacies without fossils (vicinity of Rychnov and Politz.)
(3) Quader facies with *Inoceramus labiatus.*
(4) Littoral phase with *Exogyra* and *Rhynchonella* (Malnitz and Dreiamschel).

The fauna is large, including 2 Reptilia, 26 Pisces, 15 Cephalopoda, 18 Gastropoda, 85 Pelecypoda, 6 Brachiopoda, 1 Bryozoa, 10 Crustacea, 7 Echinodermata, 8 Porifera, and 11 Foraminifera. Numerous forms are identical with those from the *Craie marneuse* of France, and the age is unquestionably Lower Turonian. The Weissenberger beds are capable of subdivision into three substages:

Wehlowitzer Pläner.
Launer Kalknollen.
Malnitzer Grünsand.

Nearly all the plants named come from the upper or Wehlowitzer unit, which also contains the most extensive fauna. The plants embrace the following species:

Abies calcaria Velenovsky
Caulerpites montalbanus Reñger[1]
Chondrites targionii Sternberg[1]
Cinnamomum primigenium Ettingshausen
Credneria sp. Frič
Cunninghamia stenophylla Velenovsky
Cyparissidium gracile Heer
Equisetum amissum Heer
Eucalyptus geinitzi Heer
Eucalyptus schübleri (Heer) Hollick
Ficus atavina Heer
Ficus krausiana Heer
Ficus peruni Velenovsky
Fricia nobilis Velenovsky
Geinitzia cretacea Unger
Libocedrus veneris Velenovsky
Microzamia gibba (Reuss) Corda
Myrica longa Heer
Pinus quenstedti Heer
Pinus sulcata Velenovsky

[1] Doubtful algæ-like remains.

Sequoia fastigiata (Sternberg) Velenovsky
Sequoia reichenbachi (Geinitz) Heer
Sterculia krejcii Velenovsky
Zamites familiaris Corda

The foregoing list includes eight forms peculiar to these beds, eight Perucer species and five additional Cenomanian species; one ranges up into Teplitzer beds, and *Sequoia reichenbachi* occurs at numerous older and younger horizons.

The Malnitzer beds are marine deposits somewhat less fossiliferous than the Weissenberger beds and with but one fossil plant, the wide-ranging and maceration-resisting *Sequoia reichenbachi*. They correspond to the *Inoceramus brongniarti* zone of the Saxon Turonian.

The Teplitzer beds contain an extensive marine fauna of Middle Turonian age, including 2 Reptilia, 39 Pisces, 13 Cephalopoda, 18 Gastropoda, 72 Pelecypoda, 6 Brachiopoda, 6 Bryozoa, 27 Crustacea, 9 Vermes, 10 Echinodermata, 4 Anthozoa, 26 Porifera, and 96 Foraminifera. The flora is restricted to the following species which are without special significance:

Abies minor Velenovsky
Chondrites furcillatus Rœmer [1]
Chondrites mantelli Rœmer [1]
Dacrydium densifolium Velenovsky
Fucoides ? dichotomus Frič [1]
Sequoia microcarpa Velenovsky
Sequoia reichenbachi (Geinitz) Heer

The Iserschichten, whose stratigraphic position has occasioned considerable disussion among continental geologists, are now believed to represent a littoral sand phase, representing both the Malnitzer and the Teplitzer horizons. A rather extensive marine fauna is recorded from the Iser beds, but the plants are represented by the following four worthless algæ-like remains:

Fucoides cauliformis Frič
Fucoides ? columnaris Frič
Fucoides funiformis Frič
Fucoides ? strangulatus Frič

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[1] Doubtful algæ-like remains.

The Priesener beds, first described by Reuss in 1844 as the "Pläner Mergel," transgress the Teplitzer beds. They comprise strictly marine fossiliferous marls with an abundant fauna, including 1 Iguanodon (?), 29 Pisces, 25 Cephalopoda, 55 Gastropoda, 79 Pelecypoda, 3 Brachiopoda, 3 Bryozoa, 32 Crustacea, 6 Vermes, 11 Echinodermata, 8 Anthozoa, 7 Porifera, 90 Foraminifera, and 11 Radiolaria. The greater part of the Priesener beds are referred to the Upper Turonian, although their upper portion is believed to extend into the Emscherian. The flora, while not extensive, is of considerable interest. It includes the following species:

Anthocephale bohemica Bayer
Araucaria brachyphylla Bayer
Araucaria frici Velenovsky
Ardisia glossa Bayer
Ceratostrobus echinatus Velenovsky
Chondrites furcillatus Rœmer
Diospyros primæva Heer
Ficus cecropial-lobus Bayer
Frenelopsis bohemica Velenovsky
Ilex perneri Bayer
Myrsine caloneura Bayer
Myrsine manifesta Bayer
Quercus charpenteri Heer[1]
Rhus dens mortis Bayer
Rubæphyllum gaylussaciæ Bayer
Sequoia lepidota Bayer
Sequoia reichenbachi (Geinitz) Heer
Widdringtonia parvivalvis Bayer

Of these 18 species 13 are peculiar to this horizon, 4 come up from the Perucer, or other Cenomanian beds, and 1 is common to the Teplitzer beds.

EMSCHERIAN.—The Senonian is represented in the Bohemian area by only the Emscherian or lower Senonian. The beds are generally known as the Chlomeker Schichten, although some authors segregate the lower Chlomeker under the name of the Kreibitzer Schichten. The extensive marine fauna includes 1 Mososaurus (?), 5 Pisces, 17 Cephalopoda, 60 Gastropoda, 84 Pelecypoda, 2 Brachiopoda, 1 Bryozoa, 4 Crustacea, 2

[1] A fragment not identical with Heer's Tertiary species and not certainly a *Quercus*.

Vermes, and 7 Echinodermata. Twenty of these forms range upward from the Bohemian lower Cenomanian (Korytzaner Schichten). The flora includes the following 32 species:

Alnus kefersteinii Unger[1]
Aralia chlomekiana Venenovsky
Asplenites dubius Velenovsky
Bignonia silesiaca Velenovsky
Cassia atavia Velenovsky
Cassia melanophylla Velenovsky
Chondrites furcillatus Rœmer[2]
Cinnamomum personatum Bayer
Cissites crispus Velenovsky
Cocculus extinctus Velenovsky
Credneria superstes Velenovsky
Dewalquea coriacea Velenovsky
Dryandroides geinoglypha Bayer
Dryandroides quercinea Velenovsky
Eucalyptus angusta Velenovsky
Ficus fracta Velenovsky
Gleichenia comptoniæfolia Debey and Ettingshausen
Gleichenia zippei Heer
Hymenæa elongata Velenovsky
Laurus affinis Velenovsky
Myrica acutiloba Brongniart
Phillyrea engelhardti Velenovsky
Pisonia atavia Velenovsky
Platanus onomastus Bayer
Prunus cerasiformis Velenovsky
Pteridoleimma durum Bayer
Quercus pseudo-drymeja Velenovsky
Quercus velenovskyi Bayer
Quercus westfalica Hosius and von der Marck
Rhus cretacea Velenovsky[3]
Sequoia reichenbachi (Geinitz) Heer
Smilax panartia Bayer

Over half of these come from just over the Bohemian border at Kieslingswald in southern Silesia at the foot of the Habelschwerdter Gebirges, first mentioned by Gœppert,[4] but since they are geographically a part of

[1] Very fragmentary, probably not Unger's species.
[2] Doubtful algæ-like remains.
[3] Antedated by Heer, 1872.
[4] Gœppert, Ueber die fossile Flora des Quadersandsteins von Schlesien. Nova Acta Akad. Leop.-Carol. Bd. xix, 1842, pp. 97-134, pl. xlvi-liii. Nachtrag. *Ibidem*, Bd. xxii, 1848, pp. 353-365, pl. xxxv-xxxviii.

the Bohemian flora and have all been described in papers devoted to the latter flora they are included with them in this review. Twenty-two of these plants are peculiar to this horizon in this area and two additional are confined to the Emscherian of Germany. Six are common to the Perucer beds, one additional to the Cenomanian of other areas, and one additional is common to the Teplitzer beds. The plants represent 2 supposed Algæ, 4 Filices, 1 Conifer, 1 Monocotyledon, and 25 Dictotyledonæ.

Moravia

The great Upper Cretaceous area of northern Bohemia extends southeastward into Moravia, where it is represented northward from Brünn and not far from the Bohemian border by limited areas of both the Quader and Pläner horizons. The two most celebrated localities are the plant-bearing beds at Kunstadt, about 22 miles north of Brünn, and the sandstone quarries in the Moletein valley near Mähr. Alstadt about 40½ miles northwest of Olmütz. Reuss[1] in his extended discussion of the geology of Moravia mentions (p. 740) several species of Moletein plants which had been determined by Ettingshausen. In the Moletein valley the fine-grained, irregularly bedded plant-bearing sandstone with glauconitic pockets grades upward into greensands with occasional marine molluscs. Elsewhere in the neighborhood the sand is replaced by dark clays and lignite beds. These carbonaceous clays are said to be plant-bearing, in fact Glocker (E. F.), at the Tübingen meeting of German Naturalists and Physicians in 1853, described *Cupressites acrophyllus* from these latter layers. However, the bulk of the collected material comes from the basal sandstone. Glocker collected much material in the Moletein valley which he presented to the museums at Tübingen and Stuttgart, and at the suggestion of Professors Quenstedt and Fraas these were submitted to Professor Heer[2] who made an elaborate study of the Moletein flora. His paper, published in 1869, described and figured eighteen different species,

[1] Reuss, A. E., Beiträge zur geognostischen Kenntniss Mährens. Jahrb. k. k. geol. Reichs. 5 Jahrg. 1854, pp. 659-765. (Upper Cretaceous, pp. 699-743.)

[2] Heer, Beiträge zur Kreide-flora. 1. Flora von Moletein in Mähren. Neue Denks. Schw. Gesel. Bd. xxiii, mem 2, 1869, pp. 1-24, pl. i-xi.

a number of which have been found to be important and wide-ranging types, and settled the Cenomanian age of the deposits.

The announcement of the discovery of similar plant-bearing beds near Kunstadt was made by Krasser[1] in 1889, and these were fully described by the same author[2] in 1896. Still more recently additional collections have been made from the Moletein quarries. These have not been described except in a brief preliminary paper published by Krasser[3] in 1901, and evidently large collections remain unstudied.

With the exception of the indefinite remains from the younger beds around Kwassitz and Kremsier described by Glocker,[4] no other contributions have been made to the Upper Cretaceous paleobotany of Moravia. Combining the work of the above-mentioned authors results in the following list of Cenomanian plants from Moravia:

Algæ. Krasser
Aralia decurrens Velenovsky
Aralia formosa Heer
Aralia riloba Velenovsky
Aralia wiesneri Krasser and Kubart[5]
Aralia sp. Krasser
Asplenium cf. *lapideum* Heer
Bombax argillaceum Velenovsky
Celtidophyllum præaustrale Krasser
Credneria macrophylla Heer
Cunninghamites elegans (Corda) Endlicher
Daphnophyllum crassinervium Heer
Daphnophyllum ellipticum Heer
Daphnophyllum fraasii Heer
Dipteriphyllum cretaceum (Velen.) Krasser
Dryandra cretacea Velenovsky
Eucalyptus angusta Velenovsky
Eucalyptus borealis Heer

[1] Krasser, F., Sitz. k. k. zool.-botan. Gesell. in Wien, 6 März, 1889, Bd. 39.

[2] Krasser, Fridolin, Beiträge zur Kenntniss der fossilien Kreideflora von Kunstadt in Mähren. Beitr. zur Paläontologie Oesterrich-Ungarns. Bd. x, 1896, pp. 113-152 (1-40), pl. 11-17 (1-7).

[3] Krasser, Fridolin, Bericht über eine gemeinsam mit Herrn Kubart durch geführte Bearbeitung der fossilien Flora von Moletein in Mähren. Anz. k. Akad. Wiss. Wien, 43 Jahrg. 1906, No. 4, pp. 46-47.

[4] Glocker, E. F., Ueber die Kalkführende Sandsteinformation auf beiden seiten der mittleren March, in der Gegend zwischen Kwassitz und Kremsier. Nova. Acta. Acad. Leop. Carol., Bd. xix, Suppl. ii, 1841, pp. 309-334, pl. iv.

[5] This is *nomen nudum* given by Krasser in 1906 *(op. cit.)*.

Eucalyptus geinitzi Heer
Eucalyptus schubleri (Heer) Hollick
Ficus krausiana Heer
Ficus mohliana Heer
Fungi Krasser
Gleichenia kurriana Heer
Jeanpaulia carinata Velenovsky
Juglans crassipes Heer
Magnolia amplifolia Heer
Magnolia marbodi Krasser and Kubart [1]
Magnolia speciosa Heer
Magnoliæphyllum Krasser
Majanthemophyllum cretaceum Heer
Matonidium wiesneri Krasser
Myrica indigena Krasser
Onychiopsis capsulifera (Velen.) Nathorst
Onychiopsis elongata Krasser [2]
Palmacites horridus Heer
Palmophyllum moleteiniqnum Krasser and Kubart [1]
Persea suessi Krasser [1]
Pinus protopicea Velenovsky
Pinus quenstedti Heer
Platanus acute-triloba Krasser
Platanus araliæformis Krasser
Platanus betulæfolia Krasser
Platanus cuneiformis Krasser
Platanus grandidentata (Unger) Krasser
Platanus irregularis Krasser
Platanus moravica Krasser
Platanus pseudo-guillelmæ Krasser
Platanus velenovskyana Krasser
Podozamites cf. *lanceolatus* (L. and H.) Heer
Saliciphyllum Krasser
Sapindus apiculatus Velenovsky
Sapindus saxonicus Engelhardt
Sassafras mirabile Lesquereux [3]
Sequoia fastigiata (Sternberg) Heer
Sequoia moravica Krasser and Kubart [1]
Sequoia reichenbachi (Geinitz) Heer
Typhæloipum cretaceum Krasser
Widdringtonites reichii (Ettings.) Heer

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[1] These are *nomina nuda* given by Krasser in 1906 *(op. cit.)*.

[2] This is not Geyler's nor Yokoyama's older Mesozoic species. It is identical with Atlantic Coastal Plain forms referred to *Asplenium dicksonianum* Heer, although these are probably distinct from Heer's type from the Kome beds of West Greenland.

[3] Krasser (1906) refers this to *Platanus*.

The foregoing list includes 7 ferns, including the important genera *Matonidium* and *Onychiopsis*. which represent Lower Cretaceous types that survived into later times in this area, the *Matonidium* is peculiar to the Moravian beds and the *Onychiopsis*, fortunately represented by fruiting specimens, is peculiar to the Bohemian-Moravian Cenomanian. There are 8 gymnosperms, mostly common and wide-ranging species. The 3 monocotyledons include two species referred to the palms. There are 39 Dicotyledonæ, the largest genera being Daphnophyllum (3 sp.), Magnolia (3 sp.), Eucalyptus (4 sp.), Aralia (5 sp.), and Platanus (9 sp.). One misses the species of Brachyphyllum, Cinnamomum, Salix, Celastrophyllum and the Lauraceae and Proteaceae that characterize the North American Cenomanian flora. Twenty-eight of the species are peculiar to the Moravian area. Of the 31 with an outside distribution, 18, or over 50 per cent, are types of the Perucer Schichten or Lower Cenomanian beds of Bohemia. Twelve occur in the Dakota sandstone, 9 in the Raritan formation, 9 in the Atane beds of Greenland, 7 in the Cenomanian of Saxony, 7 in the Tuscaloosa formation of Alabama, 6 in the Magothy formation, 4 in the Middendorf beds of South Carolina, 3 in the Black Creek beds and 1 in the Eutaw formation of the eastern Gulf. As might have been expected, the flora is identical with the Perucer flora and is clearly a fragment of the more extensively preserved flora of this age from northern Bohemia. The Moravian flora contains a considerable element common to North America, but has remarkably few elements common to the Cenomanian beds of Saxony and Silesia.

Dalmatia

The fossil plants collected by Bucič on the Island of Lesina off the Dalmatian coast, and forwarded to the Geologischen Reichsanstalt at Vienna, were described by Kerner[1] in 1895. The plants are either wrongly identified or else more than one horizon is represented. The character of the materials as shown in photographs would indicate that an abundant

[1] Kerner, Fritz von, Kreidepflanzen von Lesina. Jahrb. kk. geol. Reichs. Bd. xlv, Hft., 1, 1895, pp. 37-58, pl. i-v.

and well-preserved flora would reward careful collecting. Kerner records the following:

Cunninghamia elegans Corda
Daphnites gœpperti Ettingshausen
Dionnites cf. *saxonicus* (Reich) Schimper
Pachypteris dalmatica Kerner [1]
Pachypteris dalmatica dentata Kerner
Pachypteris dimorpha Kerner
Pagiophyllum araucarium Saporta [2]
Pagiophyllum rigidum Saporta [2]
Phaseolites formus Lesquereux [3]
Proteoides cf. *daphnogenoides* Heer
Proteoides sp.
Sphenolepsis kurriana Schenk
Sphenopteris lesinensis Kerner
Trichopitys sp. ?
Vaccinium sp. [4]

The presence of species found at Niederschœna in Saxony and in the Perucer beds of Bohemia would seem to indicate a corresponding age for the Lesina beds, that is to say, Cenomanian, such incongruities as are shown in the foregoing list being due to wrong identification.

Hungary

Plants of early Upper Cretaceous age have been sparingly collected from scattered localities in Hungary since Stur [5] made the initial collection at Deva (Comite Hunyad, formerly Transylvania) in the summer of 1860. Unger [6] made a contribution to this subject in 1865, and more

[1] These are types often referred to the genus *Thinnfeldia* Ettingshausen.

[2] These do not appear to be identical with Saporta's Jurassic species, but should be compared with *Araucaria toucasi* Saporta and *Araucaria bladenensis* Berry.

[3] A very doubtful identification.

[4] Probably represents *Leguminosites coronilloides* Heer, a form found in the Atane, Dakota, Raritan, and Magothy formations.

[5] Stur, D., Jahrb. kk. geol. Reichanst., Bd. xiii, 1863, pp. 33-120.

[6] Unger, F., Ueber einige fossile Pflanzenreste aus Siebenbürgen und Ungarn. Sitzungsber. k. akad. Wiss. Wein, Bd. li, Ab. i, 1865, pp. 375-380, pl. i.

recently both Staub[1] and Tuzson[2] have published additions to this flora, which is usually considered to be of Cenomanian age, although it may possibly be Turonian. The following forms are recorded:

Cedrela hazslinszkyi Unger
Comptonites antiquus Nilsson
Cryptomerites hungaricus Tuzson
Dicksonia punctata Sternberg
Geinitzia cretacea Endlicher
Juranyia hemiflabellata Tuzson (a palm)
Melastromites parvula Unger
Pagiophyllum sp. Tuzson (= *Brachyphyllum* or *Echinostrobus*)
Pecopteris linearis Sternberg
Perseoxylon antiquum Felix
Phyllites sturi Unger (*Myrtaceæ*)
Pterosphermum cretaceum Unger
Salvertia transylvanica Unger (*Vochysiaceæ*)
Widdringtonites fastigiatus Endlicher

The Tyrol and Austria

The Gosau beds, so named from the Gosau (Neue Alp) valley near Salzbourg, have been identified from scattered localities in the Tyrol and Bavaria, through the Austrian Alps, in southern Styria, and possibly in the Bakony Wald, etc., to Transylvania.[3] They represent a considerable time interval, and contain, where typically developed, a rich fauna of a Mediterranean facies, as well as the fragmentary remains of Mososaurs and Dinosaurs. There are also intercalated fresh-water or estuarine lignitic beds with fossil plants.

The relative ages and exact correlation of these scattered outcrops has been the occasion of prolonged discussion, the concensus of opinion being

[1] Staub, M., Zuwachs der phytopaläontologischen Sammlung der kgl. Ung. geol. Anstalt während der Jahre 1887 und 1888. Jahresber. für 1888, pp. 175-176, 1890.

[2] Tuzson, J., Beiträge zur fossilen Flora Ungarns II. Növénytani Közlemények, 1908, Heft 1.

[3] De Grossouvre, Rech. sur la craie supérieure, 1901.
Palfy, Földtani, xxxi, 1900.
Simionescu, Verh. k. k. Geol. Reichs., 1899, p. 227.
Redlich, Jahrb. k. k. Geol. Reichs., Bd. 49, p. 663.
Ibidem, 1900, p. 409.
Felix, J., Paläont. Bd. xlix, pp. 163-360, 1903; Bd. liv, 1908, pp. 251-339.

to regard them as representing the sedimentation in this region from the upper Turonian (Angoumanian) to the upper Senonian (Maestrichtian) (De Lapparent, Traité, ed. 5, p. 1479, 1906; Haug, Traité, p. 1320, 1911) or from the lower Emscherian (Coniacian) to the upper Aturian (Maestrichtian) (Kayser, Formationskunde, ed. 5, p. 548, 1913).

Fossil plants have been described from various outcrops, Unger,[1] as early as 1867, having published an account of a small florule from the marls of Ste. Wolfgang in upper Austria, and from the lignites of Neue Welt,[2] near Wiener Neustadt in lower Austria. Schenk[3] in 1875 described several additional forms from the Tyrol (Brandenberg near Brixlegg); Ettingshausen[15] described three species of *Pandanus* from Grünbach, Muthmannsdorf and Dreistatten in lower Austria; and more recently Krasser[4] has published a preliminary announcement of a rich flora collected by Rogenhofer at Grünbach (Neue Welt) in lower Austria. These plant-bearing beds, while their contained flora is relatively small, are clearly not older than the Angoumanian nor younger than the Santonian and may be regarded for the present purpose as of Coniacian age.

The following is a list of the forms recorded in this literature from the Gosau beds:

Carpolites oblongus Gœppert
Cunninghamites dubius Sternberg[5]
Cyparissidium cretaceum Schenk
Cyparissidium suessii Schenk
Equisetum heerii Schenk
Ficus protogæa Heer
Hymenophyllites heterophyllus Unger[6]
Hymenophyllites macrophyllus Gœppert

[1] Unger, Kreidepflanzen aus Osterreich. Sitz. k. Akad. Wiss. Wien, Bd. 55, Ab. i, pp. 642-654, pl, i, ii, 1867.

[2] Not to be confounded with the celebrated Keuper plant-beds at Neue Welt in Switzerland.

[3] Schenk, Ueber einige Pflanzenreste aus der Gosauformation Nordtirols. Paläontographica, Bd. xxiii, Lief 4, pp. 164-171, pl. xxviii, fig. 14, pl. xxix, 1875.

[15] Ettingshausen, über fossile Pandaneen, Sitz. k. Akad. Wiss. Wien. Bd. viii, 1852, pp. 493-496, pls. i-iv.

[4] Krasser, Ueber die fossile Kreideflora von Grünbach in Niederosterreich. Anzeiger k. Akad. Wiss. Wien, Bd. xliii, Jahrg. 1906, Nr. 3, pp. 41-43.

[5] This old determination of a Keuper species by Unger is entirely erroneous. It may represent *Sequoia heterophylla* Velenovsky.

[6] This is referred to *Pecopteris* by Schimper.

Leguminosites lanceolatus Schenk
Leguminosites ovatus Schenk
Lithothamnium gosaviense Rothpletz
Lithothamnium palmatum (Goldfuss) Gümbel
Microzamia gibba Corda [1]
Pandanus austriacus Ettingshausen
Pandanus pseudo-inermis Ettingshausen
Pandanus trinervis Ettingshausen
Pecopteris zippei Corda [2]
Pecopteris striata Sternberg [3]
Phyllites ehrlichi Unger
Phyllites pelagicus Unger
Phyllites proteoides Unger
Phyllites reussi Unger
Proteoides affinis Schenk
Proteoides ettingshauseni Schenk
Sequoia reichenbachi (Geinitz) Heer
Sequoia rigida Heer

According to Krasser (*op. cit.*) the following genera are represented in the material from Grünbach: Alsophila, Arundo, Banksia, Brasenia, Cussonia. Danæa, Flabellaria, Geinitzia, Grevillea, Hedera, Lygodium, Marattia, Marsilea, Matonia, Palæocassia, Pandanus, Pisonia, Platanus, Podocarpus, Proteophyllum, Quercus, Salix, Sapindus, Sapindophyllum, Trapa, Ulmus and Viburnum.

Liburnian

Along the east coast of the Adriatic in Istria, Carniola, Dalmatia and the east Adriatic littoral, the recognizable Danian is succeeded without apparent break by brackish and fresh-water deposits with *Stomatopsis, Cosina, Melania,* etc., and Chara marls containing numerous species of *Chara, Astrochara, Nitella,* and *Typha.* These constitute the Liburnian of Protocene stage of Stache.[4]

[1] Determined by Unger but is not Corda's species. It may represent *Fricia nobilis* Velenovsky.

[2] Now referred to *Gleichenia.*

[3] This is the *Aspidium reichianum* Sternberg from Niederschœna, Saxony.

[4] Stache, G., Die Liburnische Stufe. Verhandl. kk. geol. Reichanstalt, 1880, pp. 194-209.

——— Die Liburnische Stufe und deren Grenz-Horizonte. Eine Studie über die Schichtenfolgen der Cretacisch-Eocänen oder Protocänen Landbildungsperiode im Berichte Küstenländer von Osterreich-Ungarn. Abhandl. kk. geol. Reichsanstalt, Bd. xiii, 1889, pp. 1-170, pls. i-vi and map.

At Pisino (Foiba), Istria, the Blatterkalk contains Dryandra, Banksia, Lomatia, Rhamnus, Pisonia, Sapotacites, Andromeda, Myrica, Santalum, Nerium, Apocynophyllum, and Protoficus. Stache (*op. cit.*) regards this series as transitional from Cretaceous to Eocene, but the flora seems certainly to be of early Eocene age, and doubtless future field work will show the presence of a stratigraphic break, just as it has shown a similar break between the true Laramie, and the Denver and allied beds, in western North America.

THE BALKAN PENINSULA

Bulgaria

Upper Cretaceous fossil plants have been collected in connection with the study of the lignite beds of the Balkans by both Toula and de Launay. The amount of material is small, although it is not badly preserved and offers promise of a considerable flora when this little-known area shall have been thoroughly explored. The collections have been studied by Stur [1] and Zeiller,[2] resulting in the following list:

Aralia cf. *anisoloba* Velenovsky
Aralia cf. *coriacea* Velenovsky
Asplenium fœrsteri Debey and Ettingshausen
Cunninghamites elegans Corda
Dammarites bayeri Zeiller
Ficus ?
Geinitzia cretacea Endlicher
Gleichenia cf. *gracilis* Heer
Gleichenia zippei (Corda) Heer
Neritinium ?
Pecopteris cf. *haidingeri* Debey and Ettingshausen
Pecopteris (3 spp.)
Proteophyllum launayi Zeiller
Ternstrœmia crassipes Velenovsky

RUSSIA

The Cretaceous formations of central Europe disappear beneath the Tertiary and Quaternary cover in the plains of the Dniester, but appear

[1] Toula, F., Geologische Untersuchungen in Centralen Balkan. Denks. k. Acad. Wiss. Wein, Bd. lv, 1889, pp. 26, 33, pl. viii, figs. 10-12.

[2] Zeiller, R., Sur quelques empreintes végétales de la Formation charbonneuse supracrétacée des Balkans, Ann. des Mines, Xe série, tome vii, 1905, pp. 326-354, pl. vii.

again over a vast region drained by the Donetz and the Don. Recent work by Russian geologists and paleontologists has disclosed interesting faunal parallels between the Lower and Upper Cretaceous faunas of that country and those of France, England, and Germany.

Cretaceous outcrops occur over vast areas in central and northern Russia, culminating in beds of Cenomanian and Turonian age, the higher series being apparently more fully developed in the southern parts of the empire. (Crimea, Moldavia, Bessarabia, Caucasus, etc.)

A number of fossil plants, since come to be regarded as probably of Upper Cretaceous age, were recorded by Eichwald in 1865. These have been quoted by the writer in his discussion of Lower Cretaceous floras[1] and need not be republished, since the forms themselves are vague and their stratigraphic position undetermined.

Recently Kryshtofovich has announced[2] the discovery of a well preserved Upper Cretaceous flora in the Ural province. The plants recorded are the following and their age is unquestionably Cenomanian:

Asplenium dicksonianum Heer
Cissites uralensis Kryshtofovich
Pinus quenstedtii Heer ?
Platanus (Credneria) cuneifolia Bronn
Platanus (Credneria) geinitziana Unger
Platanus (Credneria) velenovskyana Krasser
Platanus sp.
Pteris frigida Heer ?
Sterculia vinokurovii Kryshtofovich
Zizyphus dakotensis Lesquereux

Fossil wood from various horizons including the Cretaceous have been described by Mercklin[3] and more recently by Kremdovskii,[4] and there

[1] Berry, E. W., Md. Geol. Survey, Lower Cretaceous, 1911, p. 132.

[2] Kryshtofovich, A., Bull. Acad. Imp. Sci. St. Pétersb. série vi, 1914, pp. 603-612, 1 pl.

[3] Mercklin, C. E. von, Palæodendrologikon Rossicum. Preisschrift. k. Akad. Wiss. St. Pétersb. 1856, 99 pp., 20 pls.

——— Sur un échantillon de bois pétrifié provenant du gouvernement de Rjäsan. Bull. Sci. Acad. Imp. Sci., St. Pétersb., vol. xxix, 1884, pp. 243-250.

[4] Krendovskii, M. E. Beschreibung fossiler Baume hauptsächlich aus dem Süden Russlands I, II. Arbeiten Naturf. Gesell. k. Univ. Charkow, vol. xiii, 1880, pp. 263-294, pls. i, ii.

are other scattered references to the Mesozoic flora too unimportant for enumeration in the present connection.[1]

UPPER CRETACEOUS ALGÆ

Gümbel,[2] Steinmann,[3] Rothpletz,[4] and other students[5] have described numerous remains of calcareous and other algæ with more or less of their structure preserved from marine beds at various horizons in the Upper Cretaceous. Since these papers usually contain material from widely scattered localities it is not usually feasible to cite them by areas, although a few of them are mentioned. They are not incorporated in detail in the foregoing discussion for the reason cited above, and also because their study has heretofore been a special field but little cultivated by either botanists or paleobotanists and is as yet in its infancy, although promising results of immense value.

[1] The writer has been unable to consult Nowak, J., Kopalna flora senonska z. Potylicza. Krakow, 1907.

[2] Gümbel, C. W., Geognostische Beschreibung des bayerischen Alpengebirges und seines Vorlandes., pp. 1-950, pls. i-xlii, Gotha, 1861.

——— Die sogenannten Nulliporen (Lithothamnium und Dactylopora) und ihre Betheiligung an der Zusammensetzung der Kalkgesteine. Abh. k. Akad. Wiss. München. Bd. xi, pt. i, 1871, pp. 11-52, 232-290, pls. i, ii, Di-Div.

——— Vorlänfige Mittheilung über Flyschalgen. Neues Jahr. Bd. i, 1896, pp. 227-232.

[3] Steinmann, G., Zur Kenntniss fossiler Kalkalgen (Siphonean) Neues Jahrb., Bd. ii, 1880, pp. 130-140, pl. v.

——— Ueber fossile Dasycladaceen vom Cerro Escamela. Beitr. Geol. Paläont. Republ. Mexico von Felix and Leuk, Ab. ii, 1899, pp. 189-204, tf.

——— Ueber Boueïna, eine fossile Alge aus der Familie der Codiaceen. Bericht. naturf. Gesell. Freiburg. Bd. xi, 1901, pp. 62-72, tf. 1-13.

[4] Rothpletz, A., Das Verhältniss der fessilen zu den lebenden Lithothamnium-Arten. Bot. Centralblatt, Bd. xlv, 1891, pp. 235, 236.

——— Fossile Kalkalgen aus den Familien der Codiaceen und der Corallineen. Zeits. deutsch, geol. Gesell. Bd. xliii, 1891, pp. 295-332, pls. xv-xvii.

——— Ueber die Flysch-Fucoiden und einige andere fossile Algen sowie über laisische Diatomeen-führende Hornschwämme. *Ibidem*, Bd. xlviii, 1896, pp. 854-914, pls. xxii, xxiv.

[5] Martin, K., Lithothamnium in cretaceischen und jüngeren Ablagerungen tropischer Inseln. Centralblatt f. Mineral 1901, pp. 161-165.

Stopes, M. C., Catalogue of Cretaceous Plants in British Museum (Na Hist.), pt. i, 1913.

CONCLUSION

The time has not yet arrived for a satisfactory discussion of the place of origin or the subsequent migrations of the great dicotyledonous flora that with seeming suddenness makes its appearance almost coincident with the dawn of the Upper Cretaceous. It may be pointed out that this apparent sudden predominance is probably based on a relatively long antecedent evolution in areas remote from regions of sedimentation.

It has been commonly assumed, and it is certainly the most attractive hypothesis, that the origin of the dicotyledons was in high latitudes from which region they spread southward over the continents of the northern hemisphere in successive waves of migration. There is considerable evidence in support of this theory, but the unexplored Cretaceous sediments of the great continent of Asia and of most of the lands in the southern hemisphere invalidates too hasty generalizations. The land mass of Asia with free land communication during Middle Cretaceous time to the northward, southward, eastward, and westward, has not received the consideration which it merits as a center of radiation, nor have the American tropics received much attention, although the writer's studies show the latter region to have unquestionably occupied a very important place in any discussions of the early Tertiary history of dicotyledonous floras. This one conclusion seems warranted, that the origin and initial radiation of dicotyledonous floras took place somewhere in the great and massed land areas of the northern hemisphere.

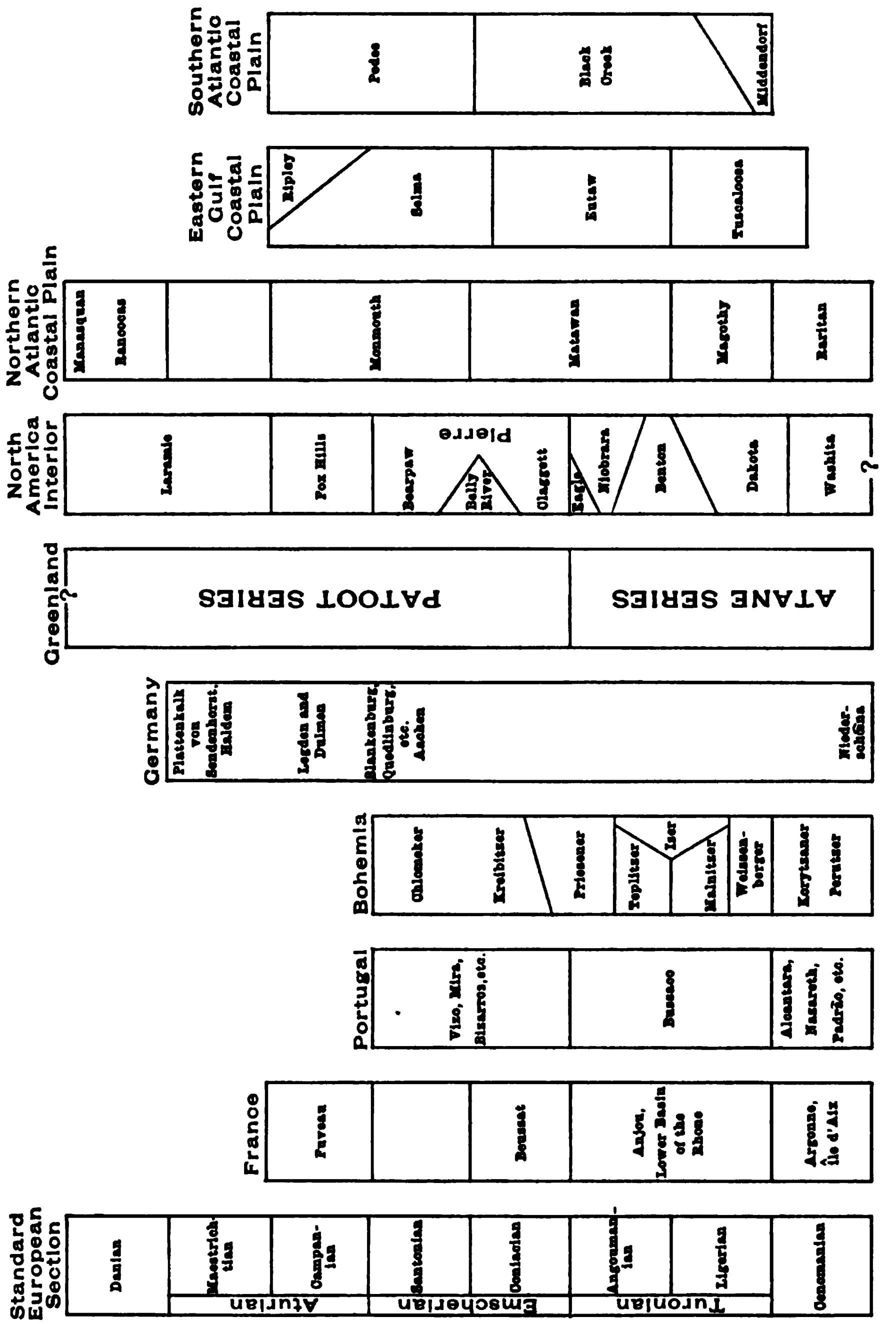
The Upper Cretaceous floras show a great modernization as compared with those of the older Mesozoic. The essentially Jurassic flora of the Lower Cretaceous with its wealth of conifers, cycads and ferns is replaced with a forest of mixed conifers and dicotyledons, the ferns occupy a subordinate position and the cycads are rapidly waning. All the species are extinct, in fact scarcely any survive into the Eocene. Many of the genera, particularly among the conifers, die out before the close of the period, and a large number of the dicotyledons are generalized and primitive types.

The physical conditions which these Upper Cretaceous floras indicate is also one that must of necessity be discussed with caution, since so little

after all is known of the real relations of organisms to their environment. In local areas with the concomitant evidence from sediments and associated faunas it is often possible to be more explicit, but in considering the floras as a whole it can only be said that they unmistakably show more uniform climatic conditions than existing floras. They can be traced from Greenland to Texas with apparently but slight changes; they cross the equator unchanged in both the eastern and western hemispheres. In general they furnish but slight evidence of deciduous habits, but prevailing show a character more like existing floras of the warm temperate rain-forest type, less tropical than succeeding Eocene and Oligocene floras.

The so-called Mediterranean faunas of both hemispheres, characterized especially by the Chamacea and Rudistacea, have often been supposed to indicate climatic zones but this may justly be doubted. Considering only the North American region it may be noted that the marine faunas of the east coast, as was true of the floras, can be traced from New Jersey to Alabama with scarcely any evidence of climatic influence. On the other hand, the Mediterranean fauna of Mexico and Texas extends northward in the Western Gulf area to about the same latitude that the Atlantic Coast fauna reaches in Alabama in the Eastern Gulf area. It is obvious that distance from the equator was not a factor as is also abundantly proven by the European record. While the effects of warm currents might be considered as of importance in Europe it is difficult to conceive any arrangement of Cretaceous currents that would affect the western and not the eastern shore of the Cretaceous Mississippi Gulf. Both faunas are conspicuously shallow-water, and the one outstanding difference is the character of the sediments—those of the Eastern Gulf and Atlantic Coast being clays and sands, while those of the Western Gulf are limestones of clear waters. It is concluded that the character of the water is the major factor and that the faunas confirm the floras in indicating but feeble if any zonal climatic differentiation.

No attempt at a detailed correlation of these widely scattered Upper Cretaceous floras that have been enumerated on the preceding pages has been considered feasible in view of their very unequal values. A few of the more important have been brought together and compared with the standard section in the accompanying table.


Southern Atlantic Coastal Plain
Pedee
Black Creek
Middendorf
Eastern Gulf Coastal Plain
Ripley
Selma
Eutaw
Tuscaloosa
Northern Atlantic Coastal Plain
Manasquan
Rancocas
Monmouth
Matawan
Magothy
Raritan
North America Interior
Laramie
Fox Hills
Pierre
Bearpaw
Belly River
Claggett
Eagle
Niobrara
Benton
Dakota
Washita
?
Greenland
?
PATOOT SERIES
ATANE SERIES
Germany
Plattenkalk von Sendenhorst, Haldem
Legden and Dulmen
Blankenburg, Quedlinburg, etc. Aachen
Nieder-schöna
Bohemia
Chlomeker
Kreibitzer
Priesener
Teplitzer
Iser
Malnitzer
Weissen-berger
Korytzaner
Perutzer
Portugal
Vizo, Mira, Bizarros, etc.
Bussaco
Alcantara, Nazareth, Padrão, etc.
France
Fuveau
Beausset
Anjou, Lower Basin of the Rhone
Argonne, Île d'Aix
Standard European Section
Danian
Maestrichtian
Campanian
Santonian
Coniacian
Angoumanian
Ligerian
Cenomanian
Aturian
Emscherian
Turonian

CORRELATION OF THE UPPER CRETACEOUS FORMATIONS

BY

WM. BULLOCK CLARK, EDWARD WILBER BERRY

AND

JULIA A. GARDNER

The correlation of the Upper Cretaceous formations of Maryland is based upon both physical and paleontological criteria. The Maryland formations extend beyond the limits of the state and especially to the northward can be traced almost continuously through Delaware and New Jersey to the islands off the New England coast, while to the southward they are buried throughout Virginia by extensive deposits of Tertiary age, although found in deep-well borings near the present coastal border at Norfolk and Old Point Comfort. Further southward in North Carolina they appear in surface exposures, and although found under somewhat different physical conditions still show similarities in their lithology and structure which suggest the practical continuity of the beds not only throughout this portion of the Coastal Plain but also farther southward to the Gulf region where, as might be expected, more pronounced differences are found. Throughout the northern and central part of the Atlantic Coastal Plain, however, the continuity of the deposits and the similarities in lithologic characters and stratigraphic sequence are such as to aid materially in the correlation of the strata that everywhere lie unconformably on older deposits whether Lower Cretaceous sands and clays, Triassic shales and sandstones, or crystallines of various types and ages.

The full sequence of Upper Cretaceous sediments is probably nowhere found within the belt of outcrop, since the unconformities hitherto

described doubtless represent intervals of deposition that may be represented by deposits now buried beneath the Tertiary mantle, but so far as known are not represented in their entirety in the surface outcrops of the existing land. As already pointed out the most complete sequence of Upper Cretaceous formations along the Atlantic border is to be found in New Jersey, where the strata have been much more minutely subdivided into stratigraphic units than is elsewhere possible. The major divisions, however, may be traced over wide areas and are clearly recognizable throughout the northern part of the Coastal Plain. Farther south, although presenting many points in common with the northern districts, the Upper Cretaceous has been somewhat differently subdivided and is described under different formational names. At the same time the general continuity of the series as a whole without doubt exists, notwithstanding the necessity for the present of the existing local designations.

The paleontologic characteristics afford ample evidence in the great number of identical species of plant and animal remains, for the correlation of the formations not only throughout the northern area but with the Upper Cretaceous strata of the south Atlantic and Gulf regions. At the same time the floras and faunas afford many forms that make possible the correlation of the deposits with more distant areas and even permit the reference of the formations to the standard Cretaceous section of Europe. The significance of the faunas and floras from the standpoint both of local and of more extended correlation will be discussed in the subsequent pages.

CORRELATION WITHIN THE NORTHERN ATLANTIC COASTAL PLAIN

The correlation of the Maryland Cretaceous formations with those of Delaware, New Jersey, and the islands off the New York and New England coasts is readily made on the basis of the continuity of the deposits, the similarity of the materials, and the stratigraphic relations of the several formations, as well as upon the basis of the identity in species of a large number of plant and animal remains.

During the past twenty years the senior author and his associates have mapped in great detail the Upper Cretaceous formations throughout

much of the district and have compared, step by step as the work has proceeded, the various physical facts relating to the stratigraphy and structure of the several formations. More recently the junior authors of this chapter have engaged in critical studies of the floras and faunas.

COMPARATIVE TABLE OF MARYLAND AND NEW JERSEY UPPER CRETACEOUS FORMATIONS

MARYLAND AND DELAWARE	NEW JERSEY	
	MANASQUAN	
RANCOCAS	RANCOCAS	VINCENTOWN HORNERSTOWN
MONMOUTH	MONMOUTH	TINTON REDBANK NAVESINK MT. LAUREL
MATAWAN	MATAWAN	WENONAH MARSHALLTOWN ENGLISHTOWN WOODBURY MERCHANTVILLE
MAGOTHY	MAGOTHY	
RARITAN	RARITAN	

The Raritan flora as developed in the Maryland area comprises only 21 species including 2 ferns, 2 cycadophytes, 1 conifer, and 16 dicotyledons. The most abundant forms, due in a measure to their maceration-resisting character, are Aspidiophyllum, Protophyllum, Platanus, and Araliopsoides. Three of the 21 species are peculiar to the Maryland Raritan. Ten of the species are common to the Raritan of the New Jersey area, while only 4 are found in the overlying Magothy formation throughout its whole extent. Only a single form, the very wide-ranging and probably composite *Podozamites lanceolatus*, ranges into the Raritan from the Lower Cretaceous.

The ten species common to the Raritan of Maryland and New Jersey are: *Asplenium dicksonianum, Cinnamomum newberryi, Czekanowskia capillaris, Diospyros primæva, Ficus ovatifolia, Fontainea grandifolia, Podozamites lanceolatus, Podozamites marginatus, Salix lesquereuxii,* and *Sassafras acutilobum.*

The four species of the Maryland Raritan that occur in the overlying Magothy of this State are *Cinnamomum newberryi, Diospyros primæva, Salix lesquereuxii,* and *Sassafras acutilobum.*

The total Raritan flora of the North Atlantic Coastal Plain when compared with that of the complete Magothy flora shows that 139 forms have not been found in the Magothy.

The Magothy flora of Maryland consists of 100 species, of which 6 are ferns; 19 are gymnosperms; 4 are monocotyledons, including the remains of a fan palm; and 69 are dicotyledons, well distributed among the natural orders. Fifty-one species, including many distinctive forms, are common to the Magothy of the area from New Jersey to Marthas Vineyard. Forty-two species occur in the Raritan flora of either Maryland or New Jersey, this large number being due primarily to the prenuntial character of the flora of the uppermost Raritan of South Amboy, New Jersey. When the Magothy flora of the north Atlantic Coastal Plain is considered as a whole, its individuality is strongly emphasized. A large number of peculiar species are present and many genera appear in the geologic record for the first time. Its distinctness from the Raritan flora is indicated by the fact that 202 Magothy species do not occur in the Raritan.

The most characteristic forms common to New Jersey and the Islands are: *Aralia ravniana, Carex clarkii, Dammara cliffwoodensis, Diospyros rotundifolia, Ficus crassipes. Ficus krausiana, Liriodendropsis constricta, Magnolia capellini, Magnolia obtusata, Magnolia tenuifolia, Moriconia americana, Populus stygia,* and *Quercus morrisoniana.*

A correlation of the Upper Cretaceous faunas of Maryland in this district must be chiefly made with the better-known faunas of New Jersey. The thesis of Weller's treatment of the Upper Cretaceous life of New

Jersey rested on the assumption that the New Jersey Coastal Plain was subjected during Upper Cretaceous times to a series of slight oscillations, and that concomitant with these oscillations of the sea bottom there was a shifting of the faunas back and forth so that a given fauna remained constantly under a given depth of water and reappeared at intervals throughout the epoch. Whether or not this alternation of faunas which Weller postulates is due to oscillations of the sea bottom or to other causes, such as a slight shifting of the in-shore currents, or a difference in the amount and character of the sediments brought down by stream erosion, is open to question.

It is highly improbable, however, that his "Cucullæa" fauna which he has found characteristic of and recurrent in the more glauconitic beds of the Merchantville, Marshalltown, Navesink, and Tinton lived at a depth of more than fifty fathoms. All of the Upper Cretaceous faunas of the Middle Atlantic Coast are essentially shallow-water faunas and it is probable that the faunal differences are due rather to varying proximity to stream mouths and sediment-bearing currents than to the relatively slight differences in the number of fathoms.

Weller's major groupings seem, in the light of the work done by Stephenson in the Southern Atlantic states, less happy. Weller recognized but two major divisions, the Ripleyan, covering all from the base of the Magothy to the top of the Monmouth, and the Jerseyan, including the Rancocas (Hornerstown and Vincentown) and Manasquan. The Ripleyan as used by the New Jersey Survey has a wider faunal range than the Ripley formation of the eastern Gulf region which, as defined for that region, is the equivalent only of the Monmouth. The formational names Matawan and Monmouth have been repudiated even as group names by the New Jersey Survey, although first used for these divisions in that state.

Weller has maintained that "from the faunal point of view the recognition of a Matawan division and a Monmouth division in New Jersey is strictly arbitrary and unnatural. Some species, to be sure, are restricted to the lower formations of the series and others to the upper, but there is

no assemblange of forms which can properly be said to constitute a Matawan fauna and another a Monmouth fauna, which are any more distinct in character than the faunas of successive formations.

"If the foreign Belemnitella element introduced in the Mt. Laurel-Navesink fauna had persisted, and had supplanted in any notable degree the older faunas in the region, instead of being a minor, although important episode in the faunal history, merely being one element in a fauna which as a whole was closely related to an earlier one, and which was followed by another one in which the Belemnitella element was absent, and which was essentially a recurrence of an earlier fauna, then there would be good paleontological reasons for recognizing the Matawan and Monmouth as distinct major divisions."[1]

The initiation of the Monmouth (Mt. Laurel-Navesink) fauna marks the introduction not only of *Belemnitella americana,* but also of *Exogyra costata, Turritella vertebroides* and its northern analogue *T. paravertebroides, Anchura pennata, Eutrephoceras dekayi,* and probably of *Liopistha protexta,* all of them forms that have served as guide fossils in separating the higher from the lower Upper Cretaceous faunal zone throughout the South Atlantic and Gulf states. These zones are so clearly defined in the south that it has been possible to differentiate them on the Federal Survey maps. While it is true that a number of the Matawan forms persist far into the Monmouth, this does not in the least detract from the significance of the initiation of a new element of more than local importance at the opening of the Monmouth.

The time of extinction of an old fauna is considered at present as a less significant fact than the time of initiation of a new one, and if that new one be sufficiently virile to characterize the molluscan life from New Jersey south through Georgia and west to Texas, it indicates something more than a minor oscillation in a restricted area and should be given the relatively higher rank which it deserves.

The Matawan is represented in Maryland and Delaware in two distinct areas, the one along the Chesapeake and Delaware Canal and the other in

[1] Weller, S., Geol. Survey N. J., Paleontology, vol. iv, 1907, pp. 177, 178.

Anne Arundel County, Maryland. The fauna of the Canal area is less homogeneous in character than that of the Anne Arundel area, and one or two of the faunal zones differentiated in New Jersey have been partially recognized in it, although they are less sharply defined than in the New Jersey area. In the immediate vicinity of Summit Bridge and at Post 105 a fauna is represented analogous to that of the combined Merchantville and Woodbury. It includes twenty-one or twenty-two species, the most characteristic of which are: *Liopistha alternata, Anchura rostrata, Turritella delmar, Laxispira lumbricalis, Mortoniceras delawarensis, Placenticeras placenta,* and *Scaphites hippocrepis. Turritella delmar* is known only from the environs of the type locality. *Laxispira lumbricalis, Anchura rostrata, Placenticeras placenta* and *Scaphites hippocrepis* are characteristic of the Merchantville of New Jersey and of the *Exogyra ponderosa zone* of the South Atlantic and Gulf regions, while *Mortoniceras* and *Liopistha alternata* are common not only to the Merchantville of New Jersey but to the basal beds of the *ponderosa zone* throughout the South Atlantic and Gulf states and to the analogous beds of the Interior. However, the Summit Bridge fauna is probably the equivalent not only of the Merchantville but of both the Merchantville and the less definitely characterized Woodbury. Even within the limits of New Jersey, Weller noticed that the differentiation between the two horizons became increasingly difficult toward the south, and in Delaware it is apparently obliterated. Both typical Merchantville forms, such as *Mortoniceras delawarensis,* and typical Woodbury forms, such as *Yoldia longifrons,* occur at a single locality, although the earlier types are dominant. The *Mortoniceras* fauna is a relatively deep-water fauna and notable for the absence of *Exogyra* and *Gryphæa* as well as the smaller oysters. In this respect it stands in marked contrast to the fauna which is most typically developed to the eastward on the Chesapeake and Delaware Canal near Post 236. By far the most conspicuous elements in this fauna, both from the point of view of abundance and also of proportions, are the ponderous Ostreids. A number of species of the smaller bivalves and univalves occur, but none of them are prolific, while the cephalopods are very rare. The general aspect of the fauna is very similar to that of

the Marshalltown of New Jersey, which like that west of St. Georges is best characterized by the abundance of *Exogyra* and *Gryphæa*. The Matawan fauna from the Magothy River in northern Anne Arundel County is meager, but is obviously more homogeneous in general character, and the horizons differentiated in New Jersey have not been recognized.

With the relatively unimportant exceptions above cited the Matawan fauna of Delaware and Maryland presents nothing to indicate the presence of the New Jersey faunal subdivisions. Furthermore, the stratigraphic units based on lithologic differences in New Jersey are not present to the south of the Delaware River, so that the New Jersey classification can at best have only a local application and even there does not represent the most significant faunal values which the terms Matawan and Monmouth imply.

Among the most characteristic Matawan forms common to Maryland and New Jersey are: *Yoldia longifrons, Exogyra ponderosa, Modiolus burlingtonensis, Liopistha alternata, Pholadomya occidentalis, Crassatelina carolinensis, Corbula bisulcata, Anchura rostrata, Laxispira lumbricalis, Placenticeras placenta, Mortoniceras delawarensis, Baculites asper.*

The Monmouth fauna is very much larger than the Matawan, much better preserved and much more cosmopolitan in its affinities. There are three areas of distribution in Maryland—one on the Eastern Shore in Cecil County, a second along the Sassafras River in Cecil and Kent counties, and a third in Anne Arundel and Prince George's counties. The Sassafras River fauna though prolific is very poorly preserved, and the determinable species are none of them diagnostic of any particular facies. The most striking difference between the Monmouth of Cecil County, as developed along Bohemia Creek, and that of Prince George's County, is in the cephalopod fauna. The cephalopods are best represented on the Eastern Shore by *Belmnitella americana,* on the Western Shore by *Sphenodiscus lobatus.* The former suggests the Mount Laurel-Navesink fauna of New Jersey, in which *Belemnitella* is exceedingly abundant and to which it is restricted. *Sphenodiscus,* on the other hand, is the most characteristic species of the Tinton and is confined to it. Aside from the presence

of *Belemnitella,* the Bohemia Creek fauna is notable for the relatively large number of Ostreids, a feature which it shares in common with the later Matawan and the Navesink of New Jersey. It differs from the Navesink, however, in the absence of a large gastropod fauna. Apparently the waters were even more shallow in the area inhabited by the *Belemnitella* than in that characterized by the presence of *Sphenodiscus* and by the relatively few Ostreids, particularly those of the more ponderous type. The *Sphenodiscus* fauna is restricted in its known distribution in Maryland to the Western Shore and, indeed, to Prince George's County. The marls containing these forms have furnished the most prolific fauna of any of the Upper Cretaceous deposits of Maryland. There is clearly no basis either on faunal or stratigraphic grounds for recognizing south of the Delaware the subdivisions of the New Jersey area, although the Monmouth fauna is extensive and characteristic.

Among the most characteristic Monmouth forms common to Maryland and New Jersey are: *Nemodon eufaulensis, Ostrea monmouthensis, Exogyra costata, Pecten simplicius, Liopistha protexta, Crassatellites vadosus, Cardium kümmeli, Corbula crassiplica, Anchura pennata, Turritella paravertebroides, Gyrodes petrosus, Eutrephoceras dekayi, Sphenodiscus lobatus, Belemnitella americana.*

The Rancocas fauna has not been discovered in Maryland, although it is quite well represented in Delaware in the vicinity of Odessa, not far from the Maryland Line. The diagnostic features of the fauna are essentially those of the Vincentown of New Jersey—a prolific bryozoan fauna with *Terebratula harlani* in abundance and a very meager molluscan representation. The mollusca of the two areas are curiously dissimilar, none of the few characteristic species of New Jersey—*Cardium knappi, Caryatis veta, Polorthis tibialis*—occurring in Delaware, while the abundant Delaware *Gryphæa* to which the characteristic Vincentown bryozoa attach themselves is apparently not present in New Jersey. It is probable that the Delaware Vincentown represents a fossil oyster bank where the ensemble of the life was, as it is to-day, very distinct from the fauna a short distance removed from the bank.

The larger formational units above described can be readily recognized in both areas on stratigraphic grounds as well, but the smaller subdivisions of the New Jersey area are not present in Maryland.

Correlation With the South Atlantic and Eastern Gulf Coastal Plain Formations

The correlation of the Maryland Upper Cretaceous formations with those of the South Atlantic and eastern Gulf states is likewise based upon both physical and paleontological criteria. Because of the extensive overlapping of Tertiary formations in Virginia, and again in parts of South Carolina and Georgia, the continuity of the Upper Cretaceous formations from Maryland southward to the Gulf is with less certainty assured. However, the known character of the deposition and the discovery of Upper Cretaceous marine strata in the deep-well borings at Norfolk and Old Point Comfort make it highly probable that such continuity exists beneath the blanket of Tertiary formations. Furthermore, the materials are similar in character, although differences are found, particularly in the great development of the Selma Chalk of the eastern Gulf. The stratigraphic position of the Upper Cretaceous strata, however, is essentially the same in the general relationships which these beds bear to underlying and overlying formations.

COMPARATIVE TABLE OF MARYLAND, SOUTH ATLANTIC AND EASTERN GULF UPPER CRETACEOUS FORMATIONS

Maryland	North and South Carolina	Georgia	Alabama
Monmouth	Pedee	Ripley	Ripley Selma
Matawan	Black Creek	Eutaw	Eutaw
Magothy	Middendorf		Tuscaloosa
Raritan			

The floras and faunas possess much in common, many identical and closely related species ranging throughout the entire district to the Gulf.

Compared with the floras of the South Atlantic and eastern Gulf Upper Cretaceous the Raritan flora of Maryland has six species, *Asplenium dicksonianum, Podozamites marginatus, Salix lesquereuxii, Cinnamomum newberryi, Sassafras acutilobum* and *Diospyros primæva,* common to the Tuscaloosa formation; three, *Cinnamomum newberryi, Ficus ovatifolia* and *Salix lesquereuxii,* common to the Eutaw formation; and five, *Cinnamomum newberryi, Diospyros primæva, Ficus ovatifolia, Podozamites lanceolatus* and *Salix lesquereuxii,* common to the Black Creek formation. In considering the Raritan flora from New Jersey to Maryland as a whole it is obvious that its latest expression in beds of Upper Raritan age, namely, those in the vicinity of South Amboy, points to the synchroneity of the uppermost Raritan with the lower Tuscaloosa of the eastern Gulf area.

The Magothy flora is much more closely related to these more southern floras. Compared with the flora of the Black Creek formation of North and South Carolina, the Magothy of Maryland has thirty-four common species and many additional closely related forms. Some of the common forms, as for example, *Araucaria bladensis, Protophyllocladus lobatus, Andromeda novæ-cæsarcæ,* etc., are highly characteristic of the two formations, and there can be no question of the synchroneity of the Magothy with a part of the Black Creek formation.

In the eastern Gulf area fossil plants are abundant in the initial Upper Cretaceous or Tuscaloosa formation, frequent in the basal beds of the overlying Eutaw formation, and practically absent in the Ripley and Selma formations. The Tuscaloosa formation embraces a great thickness of deposits and is upwards of 1000 feet thick in western Alabama. It contains a large flora very similar in facies to that of the Magothy formation of the North Atlantic Coastal Plain. Forty per cent of the Magothy flora is common to the Tuscaloosa, among the more characteristic forms being: *Andromeda novæ-cæsareæ, Bauhinia marylandica, Citrophyllum aligerum, Diospyros rotundifolia, Ficus daphnogenoides, Ficus krausiana, Geinitzia formosa, Laurophyllum nervillosum, Magnolia capellini, Mag-*

nolia hollicki, Myrica longa, Myrsine gaudini, Podozamites marginatus, Sequoia heterophylla and *Widdringtonites reichii,* and it is obvious that the floral evidence furnishes strong confirmation of that derived from the stratigraphic and structural facts, all of which point to the synchroneity of the Magothy formation with the middle and upper portions of the Tuscaloosa formation. The basal beds of the Eutaw formation in western Georgia and at a few localities in Alabama have furnished a considerable flora with which the Magothy of Maryland has fourteen species in common. These include *Andromeda novæ-cæsareæ, Doryanthites cretacea, Ficus crassipes, Ficus krausiana, Magnolia capellinii* and *Salix flexuosa.* While the evidence furnished by the floras is less complete than that furnished by the abundant faunas, as far as it is available it confirms the mutual relations of the Magothy, Black Creek and Eutaw formations.

The earliest fauna of any significance for wide correlation in Maryland is that of the *Mortoniceras subzone* of the Matawan. *Mortoniceras* has not been recognized in the Carolinas, but it has been found by Stephenson at several localities from western Georgia to northern Mississippi, where it characterizes the upper part of the Eutaw formation. In addition to the common and diagnostic *Mortoniceras* element, *Liopistha alternata* is a form restricted to this zone throughout its wide distribution. Other common forms of less stratigraphic significance are *Yoldia longifrons, Crassatellina carolinensis, Baculites asper,* and *Placenticeras placenta.* The later fauna along the Chesapeake and Delaware Canal and that of the Western Shore of Maryland are probably synchronous with that portion of the *Exogyra ponderosa zone* (Lower Selma-Ripley) lying between the *Mortoniceras subzone* of Stephenson and the *Exogyra costata zone* (Upper Selma-Ripley). The Chesapeake and Delaware Canal fauna, however, is very local in character and probably represents only a part of the time interval covered by the southern fauna. The typical and diagnostic *Exogyra ponderosa* was apparently largely restricted to the South Atlantic waters. The species occurs in the Middle Atlantic area, but it is neither so ponderous nor so common as it is farther south. The common *Exogyra* in the Camp Fox oyster bank is *E. cancellata,* a species

occurring both in the upper part of the *Exogyra ponderosa zone* and the lower part of the *Exogyra costata zone.*

Ammonites are altogether absent in the later Matawan of the Chesapeake and Delaware Canal, although *Placenticeras placenta* occurs in limited numbers in the analogous Marshalltown of New Jersey. *Scaphites hippocrepis* has been found on the Western Shore of Maryland in Anne Arundel County and fragments, probably referable to *Placenticeras placenta. Cucullæa carolinensis,* a species confined in its southern range to the *Exogyra ponderosa zone,* also occurs in Anne Arundel County.

The evidence for the correlation of the Monmouth of Maryland with the *Exogyra costata zone* (Upper Selma-Ripley) of the South Atlantic and Gulf states is much more direct. About eighty of the one hundred and eighty-seven species listed from the Gulf (approximately 43 per cent) occur in the Monmouth of Maryland. The forms restricted in their stratigraphic distribution and characteristic both of the Monmouth and the *Exogyra costata zone* include *Nemodon eufaulensis, Anomia ornata, Crenella serica, Crenella elegantula, Liopistha protexta, Crassatellites vadosus, Aphrodina tippana, Ænona eufaulensis, Turritella vertebroides,* with its analogue in Maryland, *paravertebroides,* a number of species of Pleurotomids, Pyrifusi and Liopepla, *Eutrephoceras dekayi, Scaphites conradi* and *Sphenodiscus lobatus.* This similarity, striking as it is, will doubtless be rendered more so with further investigations of the Gulf fauna. Very little systematic work has been published since the days of Conrad and Gabb, and there is no doubt that rather a large percentage of the new species described from Maryland is represented in the Gulf. The more cosmopolitan character of the Monmouth molluscan faunas as opposed to the Matawan is probably due to a slight increase in the depth of the water and the breaking down of the barriers either of land or currents of water, which may have prevented the free intermingling of the northern and southern faunas.

The correlation of the lower part of the Upper Cretaceous series of Maryland with that of Texas has been established on the evidence of the flora. The Eagle Ford contains a considerable fauna which is comparable to the Benton in the Western Interior section, but there is no

direct faunal evidence for correlating it with the Magothy of Maryland, with which, however, it is probably in part synchronous. The correlation of the Austin chalk with the *Mortoniceras subzone* has already been suggested by Stanton[1] and by Stephenson.[2]

The Texas fauna is remarkable in that it exhibits very clearly the southern facies, as typified by *Radiolites,* which characterizes the Upper Cretaceous deposits of both the eastern and western hemispheres. It was furthermore laid down in much deeper water than the *Mortoniceras subzone* of Maryland or of the greater part of the Gulf. In spite of the differences in facies and the very imperfect knowledge of the Texas Cretaceous faunas, four, or possibly five, of the twelve or thirteen species which in the South Atlantic states and Gulf are restricted to the *Mortoniceras subzone* have been identified from the upper part of the Austin chalk. These are: *Ostrea diluviana* and the four ammonites, *Placenticeras planum, Placenticeras gaudalopæ, Mortoniceras aff. texanum,* and *Baculites (?) anceps.* Four additional species from the small Austin fauna are restricted to the *Exogyra ponderosa zone* (sensu lato), namely, *Gryphæa aucella, Exogyra ponderosa, Radiolites austinensis* and *Baculites asper.* In short, four out of the six species of ammonites which have been determined from the *Mortoniceras subzone* of the Gulf occur in the Austin chalk, while one of the two remaining is represented by a very closely allied form. The affinities to the ammonites of the *Mortoniceras subzone* of Maryland are only a little less obvious. *Baculites asper* is present in both, while *Mortoniceras delawarensis* has a close analogue in *Mortoniceras texanum,* and *Placenticeras placenta* in *Placenticeras planum* and *P. guadalopæ.* On the other hand, *Placenticeras placenta* is recorded by Meek from the Colorado group of the West, and Stanton states that still more typical forms of this species occur in association with *Buchiceras swallovi* in the *Inoceramus labiatus zone* (Eagle Ford formation) of Texas.

The only critical species which has been determined from the Taylor marls, which overlie the Austin, is *Exogyra ponderosa.* The correlation

[1] Stanton, T. W., 1909, Jour. Geol., vol, xvii, p. 419.
[2] Stephenson, L. W., 1914, U. S. Geol. Survey, Prof. Paper 81, p. 32.

of the Taylor with the upper portion of the *ponderosa zone* is at once suggested, though it cannot be proved until the Taylor is better known. The upper glauconitic clays and sands of the Navarro, however, have yielded a typical Monmouth fauna which includes such diagnostic species as *Exogyra costata, Turritella vertebroides,* and *Sphenodiscus lobatus*, together with a large number of less abundant and less ubiquitous forms, a number which will doubtless be greatly increased with the wider knowledge of the faunas.

In Arkansas the presence of *Exogyra ponderosa* in the Brownstown formation suggests its correlation with the Matawan, while the Marlbrook, Nacatoch and Arkadelphia formations have in common with the Monmouth *Exogyra costata* and *Ostrea subspatulata.*

CORRELATION WITH OTHER AMERICAN AREAS

The Upper Cretaceous deposits of Maryland are correlated with other American areas chiefly on the basis of the floras and faunas. A considerable number of plants identical in species with those of the Raritan and Magothy formations have been found in the western part of the United States, while a number of additional related forms have also been observed. There are very many characteristic genera which are of much value in determining approximate equivalency of the deposits. Compared with the flora of the Dakota sandstone of the Western Interior, the Raritan flora of Maryland furnishes the large number of ten common species, which in itself should refute the opinion of the few geologists who are inclined to consider the Raritan as of late Lower Cretaceous age.

The Magothy flora is much more closely related to the Dakota flora than is the Raritan flora, and it is believed that the two are in part synchronous. This is indicated not only by the large number of identical and closely related species but by the stratigraphic evidence. The Washita, considered by Hill and others as the uppermost division of the Lower Cretaceous, contains a fauna and a flora considered by competent paleontologists as Cenomanian in age. It therefore seems probable that the overlying Dakota is referable to the same stage as the marine Benton, namely, to the Turonian.

COMPARATIVE TABLE OF MARYLAND, WESTERN GULF, WESTERN INTERIOR, AND PACIFIC COAST UPPER CRETACEOUS FORMATIONS

Maryland	Texas	Arkansas		Western Interior	Pacific Coast
Rancocas				Laramie	
Monmouth	Navarro	Arkadelphia Nacatoch Marlbrook	Montana	Fox Hills Pierre	
Matawan	Taylor Austin	Annona Brownstown	Colorado	Niobrara Benton	Chico
Magothy	Eagle Ford Woodbine	Bingen		Dakota	
Raritan	Washita				

The Magothy flora as developed in the Maryland area furnishes thirty-six species that are common to the Dakota sandstone. It contains in addition eight closely related species, and in their generic facies the two floras are very similar. On the other hand, the Magothy flora shows no points of contact with the floras of the Montana group of the Western Interior, except such as are furnished by certain long-lived and long-ranging species like *Sequoia reichenbachi* and *Cunninghamites elegans,* which are without significance in close correlation.

At least the middle and upper portions of the Upper Cretaceous are present in the Mexican section. The faunas are most closely related to those of Texas and possess in common with them an abundance of rudistids and corals, elements which characterize the southern facies in the western as well as in the eastern hemisphere. The Mexican faunas contain, in addition, some of the species which have proved the most trustworthy horizon markers along the East Coast and Gulf and in the Western Interior. *Inoceramus labiatus,* the type fossil of the Benton in this country and of the Turonian in Europe, has been reported from Durango near Juarez, Parras and Peyotes in Coahuila and Mazapil in Zacatecas. The overlying strata in Coahuila which have been correlated with the Emscher by Aguillera [1] are barren shales and limestones. Above these are sandstones containing *Exogyra ponderosa* and *Anomia argentaria.* The *Exogyra costata zone* is even better defined than the *ponderosa* and contains, in addition to the type species, *Sphenodiscus lenticularis* or *lobatus, Eutrephoceras dekayi* and *Crenella elegantula,* a small bivalve restricted in its known distribution to the Monmouth and the Fox Hills. No Cretaceous fauna above that of the *costata zone* has been differentiated in Mexico.

The correlation of the Maryland Upper Cretaceous faunas with those of the Western Interior is much less direct than with those of the Gulf. However, some of the cephalopods and Dentalia discovered a channel of communication which was followed by a few bivalves. The fauna of the

[1] Aguillera, J. G., Guide des excursions de Xe Congrès géologique international, Mexico, (c) pp. 240-242.

two lower divisions of the Upper Cretaceous, the Raritan and Magothy, is too insufficient to afford a basis of correlation with the Dakota and Benton, but there seems to be a good reason, both in the general and in the detailed aspect of the fauna, for correlating the Matawan with the Niobrara and the Pierre, at least in part, and the Monmouth with the Fox Hills.

The lowest Matawan contains the elements of one of the best characterized and widely distributed faunas of the entire Cretaceous. The diagnostic genus of this fauna is *Mortoniceras,* the analogue in the upper Colorado of *Prionotropis* and *Prionocyllus* in the lower. Although isolated species of *Mortoniceras* have been reported from strata as old as the Albian and as young as the Campanian, the genus is abundantly present only at the horizon which it characterizes. In the United States it is entirely restricted to the basal Matawan of Maryland, the Merchantville of New Jersey, the Tombigbee sand member of the Eutaw, the Austin chalk in the Gulf, and the Benton and Niobrara of the West.

Conditions in the Western Interior during Upper Cretaceous time were quite unlike those on the East Coast. In Maryland the ammonites are, for the most part, restricted to the lower Matawan. The upper Matawan faunas all present a littoral facies in which the ammonites are almost or altogether absent. In the Western Interior, on the other hand, clear-water conditions and the concomitant ammonite faunas persisted through the Pierre. In fact, *Mortoniceras* and *Baculites asper* are the only cephalopods common to the lower Matawan of the East Coast and the Western Interior which have not been recognized in the Pierre as well as in the Niobrara. The extinction of the sensitive group of Prionotropids at the close of the Niobrara is especially significant.

Although the restriction of *Mortoniceras,* together with *Baculites asper,* to the *Mortoniceras subzone* in Maryland and to the Benton and Niobrara in the Interior, is the only direct evidence for the contemporaneity of the two horizons, the long-accepted correlation of the Niobrara with at least the upper part of the Austin chalk confirms indirectly the supposed time-equivalence of the horizons in question. Both the Niobrara and the Austin chalk have clear-water faunas, and their correlation is based on the identity of a large number of critical species, including *Ostrea congesta, Exogyra*

columbella, Exogyra læviuscula, Inoceramus exogyroides, Inoceramus involutus, Inoceramus umbonatus, Mortoniceras vespertinum, Mortoniceras shoshonense, and *Baculites asper.*[1] Some of these species, notably the Inocerami, are so widespread and so sensitive that they have been utilized as horizon markers in Europe as well as in America.

The *Mortoniceras subzone* and the Niobrara are probably not taxonomic equivalents, since in the Western Interior the Benton fauna in one area is contemporaneous with that of the Niobrara in another; physical conditions and the resulting faunas along the East Coast and in the Western Interior during the Matawan were too dissimilar to admit of so exact a correlation, but the molluscan evidence is consistently in favor of the synchroneity of their characteristic faunas. In Maryland, not only the ammonite fauna peculiar to the horizon disappeared at the close of the *Mortoniceras subzone,* but most of the cephalopods peculiar to the entire formation. In the clearer waters of the Interior, however, they survived until the close of the Pierre.

Of the four remaining Matawan ammonites which have been reported from Maryland, *Baculites ovatus, Pachydiscus complexus,* and *Placenticeras placenta* are represented in the Pierre either by identical species or forms so closely allied that they have been confused in the synonymies. *Scaphites hippocrepis,* however, has no western analogue. On the other hand, *Mortoniceras* is represented in the Benton by two species (*shoshonense* Meek and *vermillionense* Meek and Hayden) which Meek and Stanton both consider as not improbably identical with *Mortoniceras texanus.*

In the Monmouth physical conditions were reversed; there was a slight deepening of the seas along the Atlantic coast which cut out the extensive oyster banks and permitted a few of the ammonites to thrive. There is no reason to believe, however, that the waters ever exceeded 50 fathoms in depth. In the Western Interior, on the other hand, there was a decided shallowing of the seas which greatly reduced the number of Inocerami and other clear-water genera which flourished in the Pierre. The ammo-

[1] Stanton, T. W., 1893, Bull. U. S. Geol. Survey, 106, p. 48.

nite faunas of the Monmouth and Fox Hills are very similar in both their general and specific make-up. The group is represented in Maryland by *Sphenodiscus lobatus, Scaphites conradi,* and *Belemnitella americana. Sphenodiscus lobatus* has a western analogue in *S. lenticularis,* which is so closely allied that they have been constantly confused in the synonymies. *Scaphites conradi* occurs in the Fox Hills in its typical form together with a couple of varieties. *Belemnitella americana* is represented in the West by the closely related *B. bulbosa.* All of these forms, both the western and the eastern, are restricted in their distribution to the horizon which they characterize. All of the three Maryland species are more or less widely distributed along the East Coast and Gulf and have proved trustworthy time markers wherever they occur. *Eutrephoceras dekayi,* though restricted to the Monmouth in Maryland, ranges more widely in the Western Interior. There is also a general similarity in the Pelecypods and Gastropods, although there are few identical species. The Cucullæas, so prominent in the Monmouth faunas, have a goodly representation in the Fox Hills. In fact, most of the taxodont groups, the Nuculas, Yoldias, Ledas, Arcas, and, in the Fox Hills, Glycymerides, are abundantly represented both on the East Coast and in the Interior. The Anomalodesmacea and Teleodesmacea, on the other hand, constitute minor elements in both. In the univalves, the Opisthobranchs, Pyropses and Pyrifusi stand out conspicuously in the Fox Hills as well as in the Monmouth. *Anchura* is present in both, though less abundant than in the earlier faunas. *Turritella* is curiously absent in the Western Interior and the Naticoids relatively rare. All in all, however, physical conditions in the Western Interior and on the East Coast were much more similar and the consequent faunas more directly comparable during the Monmouth than at any other horizon of the Upper Cretaceous.

Along the Pacific Coast the Upper Cretaceous is represented by the Chico series, which contains a littoral fauna that has been recognized from the Yukon to Lower California. The general facies is Indo-Pacific rather than Atlantic or even Interior, so that there is little evidence for direct correlation with the Maryland series. Stanton[1] who has studied

[1] Stanton, 1909, Jour. Geol., vol. xvii, p. 419.

both the Pacific and the Western Interior fauna considers that "In time range the Chico formation apparently began somewhat earlier and continued somewhat later than the Colorado fauna of the interior seas, but it did not extend to the end of the Cretaceous, and latest Cretaceous time is probably not represented by marine deposits on the Pacific Coast."

CORRELATION WITH EUROPEAN STRATA

The correlation of the Maryland Upper Cretaceous formations with European deposits can be at best only approximate since only a few identical species have been recognized. A number of additional forms show close affinities with those of remote areas, but in general the correlation can only be determined on the basis of the facies of the floras and faunas.

In a detailed study of the Raritan flora, as developed in the argillaceous beds of the New Jersey area from which one hundred and sixty-six species of plants were described in 1910,[1] it was shown that in terms of the European section the Raritan was unquestionably Cenomanian in age. This conclusion receives additional confirmation from the present study.

The Magothy flora because of its resemblance to that of the Raritan has also been considered to be of Cenomanian age, although it has several times been suggested[2] that it represents the Turonian stage. The paleobotanical studies carried out during the past ten years and covering the Coastal Plain from New York to Texas completely confirm this opinion. At least six Magothy species occur in the Turonian of Europe, while several additional are represented in the two areas by closely related forms, the additional facts upon which this conclusion is based being found in the appended tables of distribution and in the chapter on Upper Cretaceous floras of the world.

The earliest Upper Cretaceous fauna in Maryland which affords any adequate basis for correlation is the *Mortoniceras* fauna of the Matawan. Although *Mortoniceras* is less restricted in its stratigraphic range in

[1] Berry, E. W., Jour. Geol., vol. xviii, 1910, pp. 252-258.

[2] *E. g.* in 1912, in The Coastal Plain of North Carolina, pp. 309-312.

Europe than it is in this country, yet it is peculiarly characteristic of the Emscher. The Delaware species, *Mortoniceras delawarensis,* has been reported in a number of the European check-lists from the lower Campanian, but the European form differs from the American in the regular bifurcation of the costæ and probably is at most a descendant of the American species. *Baculites asper* is common to both the *Mortoniceras subzone* and the Emscher, but it has been reported from the Santonian of Westphalia as well as from the Coniacian. *Placenticeras placenta* has also been reported from the Emscher, but the determination is by no means certain. The Niobrara fauna contains in the Inocerami additional criteria for correlating widely separated faunas. Out of the four species listed from the Niobrara, two, *Inoceramus umbonatus* and *I. exogyroides,* are considered specifically identical with forms restricted to the Emscher. Both of the Inocerami in question occur in the Austin chalk, but they have not been recognized from any other horizon. *Gryphæa vesicularis,* a species rare in the *Mortoniceras subzone,* is widely distributed through the upper part of the Upper Cretaceous, but it has never been recognized in strata older than the Emscher; in fact, in the opinion of the junior author, none of the species of the *Mortoniceras subzone* has been identified from as early a horizon as the Turonian, nor do any of them show any marked affinities to faunas contained in strata of that age.

The most striking feature of the European Upper Cretaceous faunas is the dissimilarity between the northern and the southern. The northern fauna has been recognized in England, northern France, Germany, Russia and Scandinavia; the southern throughout the Mediterranean province. This segregation holds good not only for the European continent but also in the Asiatic, African and North American regions.

The northern faunas are characterized by the abundant presence of *Aucella, Polyptychites* and *Cylindroteuthis* in the Lower Cretaceous, and *Inoceramus, Actinocamax* and *Belemnitella* in the Upper, and by the comparative or complete absence of the Diceratids, the Rudistids and the reef corals.

The southern fauna is characterized by the abundance of the reef-building corals and of *Orbitolina,* the Diceratids, *Phylloceras, Leptoceras,*

in the Lower Cretaceous and of the Caprinids, the Radiolitidæ, the Hippuritidæ, the Ceratites and the Belemnite genera *Duvalia* and *Belemnopsis,* and by the absence of *Aucella, Inoceramus, Actinocamax* and *Belemnitella.*

The Upper Cretaecous beds of northern and central Europe occur for the most part in five more or less distinct provinces which have in common a dominantly molluscan fauna. In this they all differ from the clear-water fauna of the English chalk which is conspicuous for the abundance of the Echinoids and is, for that reason, less comparable with the Cretaceous of the Middle Altantic states than the continental faunas.

The upper Matawan of Maryland has been tentatively referred to the lower Campanian, although the paleontologic evidence for the correlation is very meager. The single common ammonite, *Scaphites hippocrepis,* is restricted in its European distribution to the lower zones of the Campanian. *Gryphæa vesicularis* and *Ostrea larva* are also common to both continents, but they range so widely that their occurrence is insignificant.

The Monmouth fauna is comparable to that of the upper Campanian, or *Belemnitella mucronata zone.* To be sure, none of the three characteristic Monmouth cephalopods, *Sphenodiscus lobatus, Scaphites conradi,* and *Belemnitella americana,* are represented in Europe by identical species, but their analogues, *Sphenodiscus lenticularis, Scaphites pulcherrimus,* and *Belmenitella mucronata,* are so closely related that they have been confused in the synonymies. *Baculites anceps,* one of the characteristic Fox Hills species, is common in the Maestricht beds. *Inoceramus barabini* of the *Exogyra costata zone* of the Gulf and of the Fox Hills has been considered a varietal form of *I. cripsii,* so abundant in the upper Campanian of England and the continent. *Gryphæa vesicularis* and *Ostrea larva* in some of its manifestations are common in the Campanian as well as in the Santonian. None of the Monmouth forms represented in Europe by identical or closely analogous species are restricted to a lower horizon than the upper Campanian, excepting *Eutrephoceras dekayi,* a species which in the Western Interior is restricted to the Pierre.

There is little direct evidence for the correlation of the Rancocas with the Danian, but the general facies of the faunas is strikingly similar.

Both are characterized by the presence of a prolific Bryozoan fauna and by the absence of Belmnitella. The molluscan fauna is relatively meager as well as absolutely so, and affords little direct basis for comparison. *Terebratula* is rather abundant in both formations but none of the species are identical.

CORRELATION WITH INDIA

The correlation of the Upper Cretaceous deposits of the Middle Atlantic states with India must of necessity be, for the most part, indirect, by the way of the European beds, the route probably followed by the original faunas, since the few species which are common are those occurring in the European deposits as well, while the Indian element present in the West Coast Upper Cretaceous faunas apparently did not penetrate into the Western Interior.

Three formations were definitely recognized by Stoliczka who mono graphed the Indian fauna, the Ootatoor which he correlated with the Cenomanian, the Trichinopoly which he considered as Lower Turonian, and the Arrialoor, regarded as Upper Turonian in part and in part Senonian. As Stoliczka suspected, these faunas are not homogeneous. It is probable that three horizons are represented in the Ootatoor, one below the Cenomanian, one synchronous with it, and a third above it. The lower horizon carries a number of cephalopods, including *Mortoniceras inflatum,* which characterize the Albian. The second horizon carries *Acanthoceras rhotomagense* and *A. mantelli,* the diagnostic ammonites utilized by Stoliczka for correlating the Ootatoor with the Cenomanian. The upper horizon of the Ootatoor contains *Inoceramus labiatus,* world-wide in its distribution in the Turonian and genarally accepted as a trustworthy guide fossil of that period. In the Western Interior this species has proved to be characteristic of the Benton and its absence from the overlying Niobrara is considered evidence of the post-Turonian age of the latter.

The fossil remains of the Trichinopoly as well as those of the Ootatoor seem to represent three distinct life zones. Only the lower horizon contains a fauna considered by the later European geologists as Turonian in its affinities, chiefly because of the presence of a Baculite closely allied to

bohemicus. The second horizon contains a rather meager fauna, but in it is an ammonite identified with *Peroniceras westphalicum,* one of the diagnostic guide fossils of the Coniacian. The upper horizon, the only one which is abundantly fossiliferous, contains both Echinoderms, such as *Marsupites milleri,* and Mollusca, such as *Trichotropis konincki, Cytherea plana* and *Eriphyla lenticularis,* which in their European distribution are restricted to the Santonian. The more direct evidence for the partial synchroneity of the Matawan with the Trichinopoly is suggested by the presence of an ammonite analogous to, if not identical with, *Placenticeras placenta.* Other identical but more wide-ranging species are *Pecten quinquecostata* and *Gryphæa vesicularis.*

The Arrialoor, as well the underlying Upper Cretaceous formations, lends itself to a triple division. The lower and middle horizons are included within the Campanian and possibly within the Upper Campanian. The fauna of the middle Arrialoor is most nearly comparable to the Monmouth and contains *Pachydiscus golvillensis, Ostrea ungulata* and other forms which characterize the *Belemnitella mucronata* zone of the continent of Europe.

Significant similarities to the Monmouth are found in the general aspect of the faunas. Out of the two hundred and sixteen bivalves listed by Stoliczka one hundred and thirty-two, or approximately 60 per cent, are referable to the Prionodesmacea. Affinities in the gastropod fauna are suggested by the Anchuras, the Volutes, Pugnellus and Turritella, especially the Indian form *Turritella breantiana* and the American *T. trilira.* Four of the Chamacæa occur, suggesting a very slight affinity with the south European faunas. One of the peculiar elements in the Indian gastropod fauna is the large Cerithium fauna, suggesting a shallowing or embayment of the sea sometime during the Arrialoor.

The upper Arrialoor contains *Nautilus danicus,* the type fossil of the lower Danian, together with large numbers of foraminifera, particularly Orbitoids.

CONCLUSIONS

The evidence afforded by the fossil plants as given in the preceding pages furnishes a strong presumption that the Raritan is of Cenomanian age and that the Magothy is of Turonian age. The evidence afforded by

the molluscan faunas of the Matawan and Monmouth, while they furnish fewer elements for correlation with Europe, appear to indicate that the Matawan is of Lower Senonian (Emscherian) age and that the Monmouth is of Upper Senonian (Aturian) age. There is in this an apparent agreement in the two lines of evidence. This is only apparent, however, for the meager Magothy fauna found in the New Jersey area shows a great resemblance to that of the succeeding Matawan, while in the South Atlantic Coastal Plain a flora of a Magothy facies occurs in beds interbedded with those carrying an invertebrate fauna of a Matawan facies. In Texas the Woodbine sand carries a flora of a Magothy facies, while the Eagle Ford formation intervenes between this horizon and that of the Austin chalk carrying Mortoniceras, which is the chief form relied upon by invertebrate paleontologists to characterize that horizon. The fact that this genus ranges upward from the Lower Cretaceous and is found in Europe and Asia as well as North America in faunas which have little else in common might raise the question of its exact contemporaneity throughout this great range. Moreover, if the Raritan is Cenomanian, as seems established, the consideration of the Matawan as Lower Senonian (Emscherian) involves the assumption that the Magothy also is Lower Senonian (Emscherian) and totally disregards the evidence of the flora of the Magothy and Black Creek formations, which contain a number of characteristic Turonian forms. The stratigraphic evidence for such a break between either the Raritan and Magothy or the Magothy and Matawan is wanting. It would seem, when local workers are not in agreement regarding the correlation of the faunas of the Westphalian plain with those of the Belgian border, that intercontinental correlations either on the evidence of the floras or of the faunas cannot with the facts now available be considered conclusive. A somewhat middle ground as possibly being more nearly in accord with the real situation is taken in the appended table of correlation, which is to be regarded more as a tentative suggestion than an established correlation, for which latter sufficient evidence may never become available.

TABLE SHOWING THE APPROXIMATE CORRELATIONS OF THE MARYLAND UPPER CRETACEOUS FORMATIONS

N. J.—Md.	N. C.—S. C.	Eastern Gulf	Western Gulf	Western Interior	Europe
Manasquan				Laramie	Danian
Rancocas					
Monmouth	Peedee	Ripley / Selma	Navarro	Montana	Senonian
			Taylor		
Matawan	Black Creek	Eutaw	Austin	Colorado	Turonian
			Eagle Ford		
Magothy	Middendorf	Tuscaloosa	Woodbine	Dakota	
Raritan			Washita		Cenomanian

SYSTEMATIC PALEONTOLOGY

OF

THE UPPER CRETACEOUS DEPOSITS OF MARYLAND

BY

R. S. BASSLER
EDWARD WILBER BERRY
WILLIAM BULLOCK CLARK
JULIA A. GARDNER
HENRY A. PILSBRY
LLOYD W. STEPHENSON

SYSTEMATIC PALEONTOLOGY

UPPER CRETACEOUS

VERTEBRATA .... EDWARD WILBER BERRY.
ARTHROPODA .... HENRY A. PILSBRY.
MOLLUSCA .... JULIA A. GARDNER.
MOLLUSCOIDEA.
    BRACHIOPODA .... JULIA A. GARDNER.
    BRYOZOA .... R. S. BASSLER.
VERMES .... JULIA A. GARDNER.
ECHINODERMATA .... WM. BULLOCK CLARK.
COELENTERATA .... LLOYD W. STEPHENSON.
THALLOPHYTA .... EDWARD WILBER BERRY.
PTERIDOPHYTA .... EDWARD WILBER BERRY.
CYCADOPHYTA .... EDWARD WILBER BERRY.
CONIFEROPHYTA .... EDWARD WILBER BERRY.
ANGIOSPERMOPHYTA .... EDWARD WILBER BERRY.

VERTEBRATA

CLASS REPTILIA

Order CROCODILIA

Suborder EUSUCHIA

Family TOMISTOMIDAE

Genus THORACOSAURUS Leidy

THORACOSAURUS NEOCÆSARIENSIS (DeKay) Leidy

Plate VIII, Figs. 1, 2

New Jersey Gavial DeKay, 1833, Ann. Lyc. Nat. Hist., N. Y., vol. iii, pl. iii, figs. 7-11.

Gavialis neocæsariensis DeKay, 1842, Zoology of New York, part iii, Reptiles and Amphibia, p. 28, pl. xxii, fig. 59.

Crocodilus (Gavialis?) clavirostris Morton, 1844, Proc. Acad. Nat. Sci., Phila., vol. ii, pp. 82-85, fig. 1.

Crocodilus clavirostris Morton, 1845, Amer. Jour. Sci., vol. xlviii, pp. 265-267, fig. 1.

Crocodilus clavirostris Giebel, 1847, Fauna der Vorwelt, Bd. i, p. 122.

Crocodilus basifissus Owen, 1849, Quart. Jour. Geol. Soc., London, vol. v, p. 381, pl. x, figs. 1, 2.

Sphenosaurus clavirostris Agassiz, 1849, Proc. Acad. Nat. Sci., Phila., vol. iv, p. 169.

Sphenosaurus clavirostris Gibbes, 1849, Proc. Amer. Assn. Adv. Sci., Cambridge, p. 77.

Sphenosaurus clavirostris Gibbes, 1851, Smith. Cont. to Knowledge, vol. ii, art. v, p. 7.

Sphenosaurus basifissus Gibbes, 1851, Ibidem, p. 13.

Thoracosaurus grandis Leidy, 1852, Proc. Acad. Nat. Sci., Phila., vol. vi, p. 35.

Crocodilus basifissus Owen, 1860, Rept. Brit. Assn., Aberdeen, p. 165.

Thoracosaurus neocæsariensis Leidy, 1865, Smith. Cont. to Knowledge, vol. xiv, art. vi, pp. 5, 115, pl. i, figs. 1-6; pl. ii, figs. 1-3; pl. iii, figs. 5-11.

Thoracosaurus neocæsariensis Cope, 1867, Amer. Nat., vol. i, p. 26.

Thoracosaurus neocæsariensis **Cope, 1869, Appendix B, Geol. of New Jersey, 1868, p. 736.**

Thoracosaurus neocæsariensis **Cope, 1869, Trans. Amer. Phil. Soc., vol. xiv, pp. 68, 79.**

Thoracosaurus neocæsariensis **Cope, 1875, Rept. U. S. Geol. Survey Terr., vol. ii, p. 250.**

Thoracosaurus neocæsariensis **Koken, 1888, Zeits. deutsch. geol. Gesell., Bd. xl, p. 757.**

Thoracosaurus neocæsariensis **Woodward, 1890, Geol. Mag., dec. iii, vol. vii, p. 393.**

Thoracosaurus neocæsariensis **Zittel, 1890, Handbuch der Palæontologie, Ab. i, Bd. iii, p. 673.**

Thoracosaurus neocæsariensis **Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 515.**

Description.—This species, the type of the genus, was figured by DeKay as early as 1833, and was rather completely described by Leidy in 1865 (*op. cit.*) from a nearly entire skull found in the Upper Cretaceous of Burlington County, New Jersey. This was compared with the existing Gavial of the Ganges and with European Upper Cretaceous *Gavialis macrorhynchus.* Leidy estimated the present form to have a skull about 3½ ft. in length, and he places the entire length of the animal at about 20 ft. It was thus one of the largest of the American crocodiles. It is represented in Maryland by the single fragmentary tooth figured.

Occurrence.—MATAWAN FORMATION. Magothy River, Anne Arundel County.

Collection.—Maryland Geological Survey.

THORACOSAURUS sp.

Plate VIII, Fig. 11

Description.—The very much broken procœlous vertebra figured is probably referable to this genus and may represent the preceding species.

Occurrence.—MONMOUTH FORMATION. Near District Line, Prince George's County.

Collection.—Maryland Geological Survey.

Family GONIOPHOLIDAE

Genus HYPOSAURUS Owen

HYPOSAURUS ROGERSII Owen

Plate VIII, Figs. 3, 4

Hyposaurus rogersii Owen, 1849, Quart. Jour. Geol. Soc., London, vol. v, p. 383, pl. xi, figs. 7-10.

Holcodus acutidens Gibbes, 1851, Smithsonian Cont. to Knowledge, vol. ii, art. v, p. 9, pl. iii, fig. 13 (New Jersey specimen, *fide* Leidy).

Hyposaurus rogersii Leidy, 1865, Smithsonian Cont. to Knowledge, vol. xiv, art. vi, pp. 18, 116, pl. iii, figs. 4, 16-21; pl. iv, figs. 1-12.

Hyposaurus rogersii Leidy, 1865, Ann. Rept. Smith. Inst. for 1864, p. 68.

Hyposaurus rogersii Cope, 1867, Amer. Nat., vol. i, p. 26.

Hyposaurus rogersii Cope, 1869, Appendix B, Geol. of New Jersey, 1868, p. 736.

Hyposaurus rogersii Cope, 1869, Trans. Amer. Philos. Soc., vol. xiv, p. 80, pl. iv, figs. 10, 11.

Hyposaurus rogersii Cope, 1875, Rept. U. S. Geol. Survey Terr., vol. ii, p. 250.

? *Hyposaurus rogersii* Williston, 1894, Kansas Univ. Quart., vol. iii, p. 3, pl. i, figs. 4, 5.

? *Hyposaurus rogersii* Williston, 1898, Univ. Geol. Survey, Kansas, vol. iv, p. 76, figs. 3, 4.

Hyposaurus rogersii Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 516.

Description.—This species, which is the type of the genus, was described by Owen in 1849 and based upon fragmentary vertebræ from the New Jersey Cretaceous. Gibbes in his description of the Mososauroid genus *Holcodus,* in 1851, included in this species a single tooth from New Jersey, which Leidy afterward showed was that of a Crocodilian. The latter author also described and figured several teeth from the Matawan formation of New Jersey. Similar teeth are not uncommon in Maryland in the Monmouth formation of Cecil County. They are fragmentary and much worn; conical; straight sides, except near the base; longitudinally ridged; about 3.5 cm. to 4 cm. in length and 1.5 cm. in maximum diameter.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, Cecil County.

Collection.—Maryland Geological Survey.

CLASS PISCES
Subclass SELACHII (ELASMOBRANCHII)
Order PLAGIOSTOMI
Suborder ASTEROSPONDYLI
Superfamily GALEOIDEA
Family LAMNIDAE
Genus LAMNA Cuvier

[Règne Animal, Tome ii, 1817, p. 126]

LAMNA ELEGANS Agassiz

Plate VIII, Figs. 5-7

Lamna elegans Agassiz, 1843, Recherches sur les Poissons Fossiles, tome iii, p. 289, pl. xxxv, figs. 1-5; pl. xxxviia, fig. 59.
Lamna elegans Gibbes, 1849, Jour. Acad. Nat. Sci., Phila. (II), vol. i, p. 196, pl. xxv, figs. 98-102.
Lamna elegans Gervais, 1852, Zool. et Pal. Franc., pl. lxxv, fig. 3.
Lamna elegans Shafhäutl, 1863, Süd-Bay. Leth. Geogn., p. 242, pl. lxii, fig. 6.
Lamna elegans Leidy, 1872, Proc. Acad. Nat. Sci., Phila., p. 166.
Lamna elegans Cope, 1875, Proc. Amer. Phil. Soc., vol. xiv, p. 362.
Lamna elegans Vincent, 1876, Ann. Soc. Roy. Malacol. Belg., tome xi, p. 123, pl. vi, fig. 4.
Lamna elegans Geinitz, 1883. Abh. naturw. Gesell. Isis, p. 5, pl. i, figs. 4-6.
Lamna elegans Noetling, 1885, Abh. Geol. Specialk. Preussen u. Thuring. Staaten, Bd. vi, Ab. iii, p. 61, pl. iv.
Lamna huttoni Davis, 1888, Trans. Roy. Dublin Soc. (II), vol. iv, p. 15, pl. iii, fig. 1.
Odontaspis elegans Smith Woodward, 1889, Cat. Fossil Fishes Brit. Museum, pt. i, p. 361.
Lamna elegans Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 309.
Lamna elegans Fowler, 1911, Bull. 4, Geol. Survey of New Jersey, p. 48, figs. 16, 17.

Description.—" L'espèce que je désigne sous ce nom est de forme élancée, régulière et droite. Son épaisseur est assez considérable près de la base de la racine, mais elle s'amincit considérablement vers la pointe. La face interne est ornée des stries verticales très-fines et fort nombreuses, qui sont surtout distinctes près de la base de l'émail, et s'étendent à-peu-prés jusqu'à la moitié de la hauteur du cône ou un peu au delà. Elles sont en

général mieux conservées dans les petites dents que dans les grandes, et tendent vraisemblablement à s'effacer à mesure que la dent grandit.

"Les dentelons latéraux sont de très-petites épines, qui atteignent à peine la grosseur d'une tête d'épingle; quelquefois même ils sont à peine sensibles ou manquent complètement. La racine est forte; ses cornes sont très-aiguisées, et assez rapprochées, quoique moins longues que dans le *L. denticulata*. La face externe est plate, voire même un peu bombée. La face interne est très-concave, ensorte que la dent a à-peu-près la forme d'un cône très-effilé, coupé par le milieu. Les bords sont tranchans. L'émail descend plus bas à la face externe qu'à la face interne; sa base est ici droite horizontale, tandis qu'elle décrit une courbe à la face interne."
—Agassiz, 1843.

Occurrence.—MATAWAN FORMATION. Summit Bridge and Post 218, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Prince George's County, Maryland.

Collection.—Maryland Geological Survey.

LAMNA CUSPIDATA Agassiz

Plate VIII, Figs. 8, 9

Lamna cuspidata Agassiz, 1843, Recherches sur les Poissons Fossiles, tome iii, p. 290, pl. xxxviia, figs. 43-50.

Lamna denticulata Agassiz, 1843, *Ibidem*, p. 291, pl. xxxviia, figs. 51-53.

Lamna hopei Agassiz, 1843, *Ibidem*, p. 293, pl. xxxviia, figs. 27-30.

Lamna dubia Agassiz, 1843, *Ibidem*, p. 295, pl. xxxviia, figs. 24-26.

Lamna cuspidata Gibbes, 1849, Jour. Acad. Nat. Sci., Phila. (II), vol. i, p. 197, pl. xxv, figs. 103-106.

Lamna cuspidata Sismonda, 1849, Mem. R. Accad. Sci. Forino (II), vol. x, p. 47, pl. ii, figs. 29-32.

Lamna cuspidata Leidy, 1872, Proc. Acad. Nat. Sci., Phila., p. 166.

Lamna cuspidata Cope, 1875, Proc. Amer. Philos. Soc., vol. xiv, p. 362.

Lamna denticulata Cope, 1875, *Ibidem*.

Lamna cuspidata Miller, 1877, Molassemeer Bodenseegeg., p. 66, pl. iii, figs. 75, 76.

Lamna cuspidata Geinitz, 1883, Abh. naturw. Gesell. Isis., p. 5, pl. i, figs. 1-3.

Odontaspis hopei Noetling, 1885, Abh. Geol. Specialk. Preussen u. Thuring. Staaten, Bd. vi, Ab. iii, p. 71, pl. v, figs. 1-3.

Odontaspis cuspidata Smith Woodward, 1889, Cat. Fossil Fishes British Museum, pt. i, p. 368.

Lamna cuspidata Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 302.

Lamna cuspidata Fowler, 1911, Bull. 4, Geol. Survey of New Jersey, p. 43, figs. 12-15.

Description.—" Cette espèce est très-fréquente dans la molasse suisse. Elle a beaucoup de rapports avec *L. elegans;* elle est en général assez épaisse, de moyenne largeur, équilatérale, droite ou un peu courbée en dedans. Les bords sont tranchans dans toute leur longueur. La face externe est sensiblement bombée; la base de l'émail y est ordinairement échancrée à angle droit, tandis qu'elle forme un angle très-prononcé à la face interne. Enfin, ce qui distingue particulièrement notre espèce du *L. elegans,* c'est qu'elle est lisse sur ses deux faces. Il importe d'autant plus d'avoir égard à ce caractère, que l'on a souvent pris pour des stries les scissures ou déchirures qui se forment dans l'émail, et qui sont sans doute un effet de la fossilisation; car on les rencontre bien plus rarement dans les dents des espèces vivantes."—Agassiz, 1843.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal, Delaware; Ulmstead Point, Magothy River, and Arnold Point, Severn River, Anne Arundel County, Maryland. MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

Genus CORAX Agassiz

[Poissons Fossiles, tome iii, 1843, p. 228]

CORAX PRISTODONTUS Agassiz

Plate IX, Fig. 1

Squalus sp. Morton, 1834, Synop. Org. Rem. Cret. U. S., p. 31, pl. xi, fig. 6.

Galeus pristodontus Agassiz, 1835, in Morton, Amer. Jour. Sci., vol. xxviii, p. 277.

Corax pristodontus Agassiz, 1843, Recherches sur les Poissons Fossiles, tome iii, p. 224, pl. xxvi, figs. 9-13.

Corax pristodontus Egerton, 1845, Quart. Jour. Geol. Soc. London, vol. i, p. 167, fig.

Galeocerdo pristodontus Gibbes, 1849, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. i, p. 192, pl. xxv, fig. 70.

Corax pristodontus Hebert, 1854, Mem. Soc. Geol. Franc. (2), tome v, p. 353, pl. xxvii, fig. 8.

Galeocerdo pristodontus Cope, 1875, U S. Geol. Survey Terr., vol. ii, p. 295.
Corax pristodontus Smith Woodward, 1889, Cat. Fossil Fishes Brit. Museum, pt. i, p. 423.
Corax pristodontus Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 309.
Corax pristodontus Fowler, 1911, Bull. 4, Geol. Survey of New Jersey, p. 64, fig. 29.

Description.—" Teeth broad, greatly compressed, and nearly wide as high. Crown greatly oblique to sometimes erect, low, and greatly compressed. Outer coronal surface usually flattened, or usually considerably less convex than inner surface, and sometimes a few basal vertical wrinkles. Latter with surface evenly convex. Apex often deflected, especially in lateral teeth. Cutting-edges finely and entirely serrated. Basal cusp sometimes present, low, broad, lateral, variable. Root very broad, deep, usually deeper than crown, compressed, surfaces slightly convex or inner flattened and sloping down below trenchant, so that lower profile is slightly emarginate. Ends of roots blunt, not produced. The lateral teeth seem to differ only in having their apices deflected to one side. Length reaches 30 mm."—Fowler, 1911.

Teeth of this low and wide compressed type are common in the Middle and Upper Cretaceous, and forms which have been referred to this species have been recorded from North America, Europe, Asia, and Africa. The species appears to have been common during Upper Cretaceous time along the east coast of North America. It ranges from the base of the Matawan upward into the Manasquan marl in the New Jersey area. In Maryland it occurs at several localities in the Matawan and Monmouth formations. South of Maryland it has been reported from South Carolina, Alabama, and Mississippi, where it is said to have come from the Eocene, but since these records are all ancient little credence can be placed in the age determination, and there is little doubt but that they are entirely Cretaceous.

Corax pristodontus is scarcely distinguishable from *Corax falcatus* Agassiz, a slightly smaller form with more inclined laterals found in the earlier Upper Cretaceous of America and Europe.

Occurrence.—MATAWAN FORMATION. Magothy River, Anne Arundel County. MONMOUTH FORMATION. Bohemia Mills, Cecil County; Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

CORAX FALCATUS Agassiz

Plate IX, Fig. 2

Corax falcatus Agassiz, 1843, Recherches sur les Poissons Fossiles, tome iii, p. 226, pl. xxvi, fig. 14; pl. xxvia, figs. 1-15.

Corax heterodon Reuss, 1845, Verstein. böhm. Kreideform, pt. i, p. 3, pl. iii, figs. 49-71.

Corax heterodon Roemer, 1852, Kreidebild. von Texas, p. 30, pl. i, fig. 8.

Corax falcatus Pictet and Campiche, 1858, Foss. Terr. Crétacé Ste. Croix, p. 80, pl. x, figs. 1, 2.

Galeocerdo falcatus Leidy, 1873, Rept. U. S. Geol. Survey Terr., vol. i, p. 301, pl. xvii, figs. 29-42.

Galeocerdo falcatus Cope, 1875, Rept. U. S. Geol. Survey Terr., vol. ii, p. 295.

Corax falcatus Smith Woodward, 1889, Cat. Fossil Fishes Brit. Museum, pt. i, p. 424.

Corax falcatus Williston, 1900, Univ. Geol. Survey, Kansas, vol. vi, p. 252, pl. xxxi, figs. 1-40; pl. xxxii, figs. 1-11.

Corax falcatus Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 309.

Corax falcatus Fowler, 1911, Bull. 4, Geol. Survey of New Jersey, p. 63, fig. 28.

Description.—Teeth variable, smaller and relatively higher than in *C. pristodontus*, moderately broad, greatly compressed. Outer coronal surface flat, inner convex. Anterior coronal margin moderately arched, apex slightly inflected. Coronal serrations generally distinct, sometimes absent in small teeth. No basal cusps. Root broad, deep, compressed, emarginate below. Length 2 cm. or less.

This species is similar to the preceding, but never attains to the maximum size of the latter. Like all of the species of *Corax* it is only known from the teeth, which are suggestive of those of the genera *Sphyrna* or *Carcharias*, but differ in the absence of an internal cavity.

Corax falcatus is a common and wide-ranging form. It is recorded from the Cenomanian or Turonian in England, France, Switzerland, Saxony, Bohemia, Galicia, and Russia; from the Senonian of England and France. In the United States it has been recorded from the Niobrara formation of Kansas and in the Atlantic Coastal Plain from New Jersey to Texas. In the New Jersey area it appears to be confined to the Monmouth and Manasquan formations, while in the South it appears to be confined to earlier horizons. In Maryland it has thus far been found only in the Matawan formation.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal, Delaware; Magothy River, Anne Arundel County, Maryland.

Collection.—Maryland Geological Survey.

Subclass TELEOSTEI

Order PHYSOSTOMI

Family ENCHODONTIDAE Smith Woodward

(HOPLOPLEURIDÆ Pictet)

"Supraoccipital bone not prominent, but extending forwards to the frontals and separating the small parietals in the median line; squamosal reduced, only partly covering the otic region, which projects laterally; no basicranial canal; snout not produced; cheek plates well developed. Mandibular suspensorium vertical or inclined backwards, and gape of mouth wide; premaxilla delicate, considerably extended and excluding a great part of the slender maxilla from the upper border of the mouth; teeth fused with the supporting bone, not in complete sockets, those on the pterygopalatine arcade and dentary the largest. Opercular apparatus complete, with few slender branchiostegal rays and no gular plate. Vertebral centra well ossined, none with transverse processes; ribs not completely encircling the abdominal cavity; a compound hypural bone at the base of the tail. Intermuscular bones present. Fin-fulcra absent; the rayed dorsal fin never much extended, usually near the middle of the back, and sometimes an adipose fin behind. Scales delicate or absent; but occasional longitudinal series of scutes, the dorsal series, when present, being unpaired.

"The nearest living allies of this extinct family appear to be the *Odontostomidæ* and *Alepisauridæ,* in both of which the margin of the upper jaw is formed exclusively by the premaxilla, while in the first the large teeth are depressible. Only three genera are known, *Odontostomus, Omosudis,* and *Alepisaurus* (*Plagyodus*), all from the deep sea."—Smith Woodward, 1901.

This entirely extinct family comprises large fusiform, laterally compressed rapacious fishes, some of which are exceedingly abundant in the

Cretaceous of various parts of the world. Nine or ten genera, chiefly Turonian and Senonian, have been differentiated, of which the largest is *Enchodus,* so abundantly represented by fragmentary remains in the Upper Cretaceous of North America.

Genus ENCHODUS Agassiz

[Poissons, Foss., Feuill. 1835, p. 55]

"Trunk elongate-fusiform, both this and the head laterally compressed. Cranial roof exhibiting a deep median longitudinal depression, its lateral and occipital margins ornamented, like the other external bones, with ridges and tubercles of granoine. Mandible a little prominent, provided with an inner widely-spaced series of large slender teeth, the largest in front, also a marginal series of minute teeth, all nearly or completely solid; premaxilla in the form of a vertical lamina, deepest in front, tapering behind, and with a single spaced series of small teeth; maxilla long and slender, either finely toothed or toothless at the oral border; palatine thickened and tumid, with only one large tooth fixed at its anterior end; ectopterygoid robust, with a single spaced series of large slender teeth, gradually diminishing in size backwards; no teeth barbed. Operculum strengthened on the inner side by a ridge extending horizontally backwards from the point of suspension; branchiostegal rays about 12 to 16 in number. Vertebræ 40 to 50 in number, about half being caudal; the centra at least as long as deep, constricted mesially, and marked with small irregular longitudinal ridges. All except the foremost rays of each fin finely divided distally, but none excessively elongated. No postclavicular plate. Pectoral fins large, pelvic fins much smaller and arising for farwards; dorsal and anal fins large, neither much longer than deep, the former arising much in advance of the middle point of the trunk, the latter also far forwards; [a posterior adipose dorsal fin observed in a few well-preserved specimens;] caudal fin forked, with curved fulcral rays and stout, articulated, undivided rays at its base both above and below. Rudimentary dermal scutes, not overlapping, in a single median series between the occiput and the dorsal fin, and along the course of the lateral

line; a pair of enlarged hook-shaped dermal scutes at the base of the tail, one on either side of the caudal pedicle.

"The cranial osteology of *Enchodus* is best known from the specimens occurring in the English and Dutch Chalk; the trunk and fins are only satisfactorily shown in the nearly complete fishes obtained from the Upper Cretaceous of Westphalia and Mount Lebanon."—Smith Woodward, 1901.

About 30 so-called species have been referred to this genus. The records include the Turonian or Senonian of England, Belgium, Westphalia, Saxony, Bohemia, and Syria; the Maestrichtian of Holland; the Niobrara and Fox Hills of the Rocky Mountain province and various horizons in the Upper Cretaceous of the Atlantic Coastal Plain.

ENCHODUS DIRUS (Leidy)

Plate IX, Figs. 3-5

Phasganodus dirus Leidy, 1857, Proc. Acad. Nat. Sci., Phila., vol. ix, p. 167.

Phasganodus dirus Leidy, 1873, U. S. Geol. Survey Terr., vol. i, p. 289, pl. xvii, figs. 23, 24.

Phasganodus dirus Cope, 1874, Bull. U. S. Geol. and Geogr. Survey Terr., vol. i, no. ii, p. 43.

Phasganodus dirus Cope, 1875, U. S. Geol. Survey Terr., vol. ii, p. 277.

Enchodus dirus Stewart, 1900, Univ. Geol. Survey, Kansas, vol. vi, pt. ii, p. 376.

Enchodus dirus Smith Woodward, 1901, Cat. Fossil Fishes Brit. Museum, pt. iv, p. 204.

Cimolichthys dirus Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 390.

Description.—The Maryland occurrence is based on the anterior part of a dentary 6.5 cm. in length, showing a large part of the anterior tooth on the alveolar border, 1.3 cm. from the front of the symphysis; and the base of a second large tooth 2.75 cm. distant from the first and 5 cm. from the symphysis. A very much reduced tooth is situated immediately behind the first, and there are traces of a second back of it. The first and largest tooth is much enlarged at the base and coalescent with the mandible. It curves considerably forward and slightly inward, and has an estimated length of 3.5 cm. The upper third is broken away. The tooth

is compressed to form a sharp anterior-lateral cutting edge, the base being excavated in front. The posterior-internal surface is full and rounded and prominently longitudinally striate.

This species was described by Leidy from a fragmentary dentary bone collected from the Fox Hills Cretaceous of Dakota, and he made it the type of a new genus, *Phasganodus*. Cope, in 1875, pointed out its identity with the genus *Enchodus*, and recently Stewart has referred material from the Niobrara formation of Kansas to this same species. The incomplete dentary figured was found in the Monmouth formation of Maryland. It is undoubtedly identical with the material described by Stewart from Kansas, but there is some question of the identity of these forms with Leidy's type. The species has not been recorded from the New Jersey Cretaceous, although some of the detached teeth made the basis of specific names might represent it.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

Order ACTINOPTERYGII

Suborder HAPLOMI

Family LUCIIDAE (ELOPIDAE)

Genus ISCHYRHIZA Leidy

[Proc. Acad. Nat. Sci., Phila., vol. viii, 1856, p. 221]

ISCHYRHIZA MIRA Leidy

Plate IX, Figs. 6-8

Ischyrhiza mira Leidy, 1856, Proc. Acad. Nat. Sci., Phila., vol. viii, p. 221.
Ischyrhiza antiqua Leidy, 1856, *Ibidem.*, p. 256.
Ischyrhiza antiqua Emmons, 1858, Rept. N. C. Geol. Survey, Eastern Counties, p. 225, tf. 47, 48.
Ischyrhiza mira Leidy, 1860, in Tuomey and Holmes, Post-Pleiocene Fossils of South Carolina, p. 120, pl. xxv, figs. 3-9.
Ischyrhiza mira Cope, 1875, U. S. Geol. Survey Terr., vol. ii, p. 280.
Ischyrhiza mira Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 398.
Ischyrhiza mira Fowler. 1911. Bull. 4, Geol. Survey of New Jersey, p. 167, fig. 103.

Description.—Teeth robust, elongate, acuminate, sigmoidal; crown conical, somewhat laterally compressed; with a large robust quadrangular fang expanding gradually to the base, which is divided by a broad basal cleft or sinus extending antero-posteriorly and deepest posteriorly. Lateral basal margins grooved or fluted. Pulp cavity expanded within the fang, closed below and narrowing toward the crown.

These teeth which apparently represent a large, powerful carnivorous sphyrænoid fish are rather widespread in the North American Upper Cretaceous. They are referred to the entirely extinct genus *Ischyrhiza* Leidy, of which the present species is the type, and are known only from detached and broken teeth. The latter with their large fangs and expanded bipartite base are very characteristic. Two or three species have been described, but it is uncertain whether or not the obviously slight variations that have been recorded are of specific value. The present species was described originally from New Jersey where it ranges from the Matawan into the Monmouth or perhaps Rancocas. It occurs in the Pedee formation of North Carolina and in the Eutaw of Ripley of Mississippi. It has also been recorded from the Ashley marls in South Carolina, where it may have been mechanically reworked from older deposits.

The Maryland material well illustrates the range of variation. The largest specimen which has lost most of the crown has an indicated length of between 5 cm. and 6 cm. The crown at the base is 12.5 mm. in antero-posterior diameter and 12 mm. in transverse diameter. Eight millimeters above the base the lateral compression has made the proportion of the two diameters as 10 to 7. The fang is 3 cm. long and about 1.7 cm. square at the base. The smallest specimen is represented by the basal part of the fang which in this case is only 5 mm. square.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal (minimum sized form). The large specimen figured is labeled "Matawan formation, Prince George's County," without further detail. Since the bulk of the materials in this county formerly considered Matawan are now known to be of Monmouth age, it seems probable that this tooth came from the Monmouth formation.

Collection.—Maryland Geological Survey.

Suborder TECTOSPONDYLI

Superfamily MASTICURA

Family MYLIOBATIDAE

Genus MYLIOBATIS Duméril

[In Cuvier, Règne Animal, tome ii, 1817, p. 137]

"Head free from the disk; so-called cephalic fin single. Teeth large, flat, sexangular, tessellated, arranged in seven antero-posterior series. The dentition of the upper jaw strongly arched antero-posteriorly, that of the lower jaw quite flat. Dental crown smooth or slightly striated; attached surface of root longitudinally ridged and grooved. Except in very young individuals—in which the teeth are all approximately of equal size—the median row is relatively very broad, while the teeth of the three lateral series of each side are rarely broader than long. Tail with a dorsal fin near its root, generally with a posteriorly situated barbed spine.

"The relative proportions of the median teeth vary with the age (or size) of the individual, the breadth gradually becoming greater with respect to the length, and in determining the fossil teeth it is necessary to allow for this change."—Woodward, 1889.

The Eagle Rays extend from the late Cretaceous to the Recent. A very large number of fossil species based on the dental pavement and caudal spines have been described especially from deposits of Tertiary age.

MYLIOBATIS OBESUS Leidy (?)

Myliobatis rugosus Leidy, 1855, Proc. Acad. Nat. Sci., Phila., p. 395 (non Meyer, 1844).
Myliobatis obesus Leidy, 1855, Proc. Acad. Nat. Sci., Phila., p. 396.
Myliobatis obesus Leidy, 1877, Jour. Acad. Nat. Sci., Phila. (II), vol. viii, p. 236, pl. xxxi, figs. 6-10; pl. xxxiv, fig. 44.
Myliobatis obesus Smith Woodward, 1889, Cat. Fossil Fishes Brit. Museum, pt. i, p. 123.
Myliobatis rugosus Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 320.
Myliobatis obesus Fowler, 1911, Bull. 4, Geol. Survey of New Jersey, p. 93, fig. 48.

Description.—"Dental plate arched in form, composed of four median teeth and at least a row of lateral teeth each side. Enamel surface in

general evenly convex. Basal surface convex, swelling to median longitudinal axis moderately. Transverse median sutures curve at first slightly convex back till posterior are quite convex. Vertical diameter of median teeth about five in horizontal diameter, their surfaces with usually distinct transverse or vertical wrinkles or nearly smooth. Length (width) 59 mm."—Fowler, 1911.

This species is recorded from the Monmouth and later Upper Cretaceous formations in the New Jersey area. Only uncertainly-determined fragments represent it in the Maryland Cretaceous.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

ARTHROPODA

CLASS CRUSTACEA[1]

Order DECAPODA

Family ASTACIDAE

Genus HOLOPARIA McCoy

The following species are referred to this genus with due reserve, as until the cephalothorax is known their exact position in the Astacoid series must remain doubtful. The *specific* characters of the fossils, however, may be readily appreciated; and the definition of the species may call attention to the matter and lead someone to search for the missing parts.

HOLOPARIA GABBI Pilsbry

Plate X, Figs. 1-4, 8, 9

Holoparia gabbi Pilsbry, 1901, Proc. Acad. Nat. Sci., Phila., p. 115, pl. i. figs. 11-14.

Holoparia gabbi Pilsbry, 1907, in Weller, Geol. Survey of New Jersey, Pal., vol. iv, p. 846, pl. cx, figs. 12-15.

[1] Former descriptions by the author have been revised in terminology and slightly changed in phrasing for this report, but only type material has been used in such revision. Information upon additional specimens is given in separate paragraphs.

Description.—Left manus robust, evenly convex on both sides, but slightly more convex externally than within, the surface slightly roughened everywhere by small flattened, separated, scale-like asperities; lower margin bluntly angular and marked by a slight groove; upper margin narrowly rounded, bearing two short conic spines on the portion preserved. These are inserted slightly below the edge on the inner side, and directed upward and forward; and on each side there is a half-round tubercle at the base of the dactylus. Pollex rather slender, with a series of coarse tubercles (worn flat) along its grasping edge. Dactylus armed with a short conic spine near its base (continuing the row of similar spines on the upper margin of the palm), its grasping face with a series of coarse tubercles worn flat. Abdominal somites with highly arched tergum, the surface punctate.

This species was based upon a left hand (figs. 8, 9) and group of four abdominal somites in the collection of the Academy of Natural Sciences of Philadelphia. A left (figs. 3, 4) and a right hand and other fragments are in the Wagner Free Institute. The pollex is broken in both specimens, and the proximal portion of the hand is wanting. In the Wagner Institute specimen the base of the dactylus remains. Breadth of hand of the type specimen 21.5 mm., thickness 13 mm.

The proximal part of a manus and a carpus are preserved in specimens from the Chesapeake and Delaware Canal. The carpus is somewhat like that of *Homarus* in shape, spinous on both sides. The surface of the manus is shown in the photograph, fig. 3.

Occurrence.—MATAWAN FORMATION. Deep cut of the Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, Academy of Natural Sciences, Wagner Free Institute of Science.

HOLOPARIA GLADIATOR Pilsbry

Plate X, Fig. 6

Holoparia gladiator Pilsbry, 1901, Proc. Acad. Nat. Sci., Phila., p. 116, pl. 1, figs. 15, 16.

Holoparia gladiator Pilsbry, 1907, in Weller, Geol. Survey of New Jersey, Pal., vol. iv, p. 848, pl. cx, figs. 16,17.

Description.—Manus long and narrow, parallel-sided, its thickness more than half the width, about equally convex on the two sides, smoothish, showing scattered punctures and under a lens a very fine punctulation; on both sides of the hand a row of three or four small pointed tubercles run lengthwise along the median convexity; lower edge bluntly biangular. Pollex nearly double the width of the dactylus, pyriform in section, with a row of tubercles along the grasping edge. Dactylus oval in section, also bearing pointed tubercles opposed to those on the pollex.

Length of manus as broken 35.3 mm.; width 11.5 mm.; thickness 7 mm.

Types are No. 10,120 collection of Wagner Free Institute of Science, and consist of an imperfect manus with broken dactylus in place, a fragment of the pollex, apparently of the same specimen, and a fragment of another hand of larger size, width 14 mm., thickness 9 mm. They were exposed by breaking hard nodules which occur in the clay at Lenola, New Jersey. Another broken manus is in the collection of the Philadelphia Academy from the deep cut of the Chesapeake and Delaware Canal in Delaware.

The species is readily recognizable by the long, narrow shape of the hand and the minute punctulation of the surface, the biangular lower edge of the pollex and hand, etc.

Occurrence.—MATAWAN FORMATION. Deep cut of the Chesapeake and Delaware Canal, Delaware.

Collections.—Wagner Free Institute of Science, Academy of Natural Sciences of Philadelphia.

Family CALLIANASSIDAE

Genus CALLIANASSA Leach

CALLIANASSA MORTONI Pilsbry

Plate XI, Figs. 1-3

? *Callianassa antiqua* Otto, 1870, Credner, Zeitsch. d. deutsch. geologisch. Gesell., Bd. xxii, p. 241.

Callianassa mortoni Pilsbry, 1901, Proc. Acad. Nat. Sci., Phila., p. 112, pl. i, figs. 1-7.

Callianassa mortoni Pilsbry, 1907, in Weller, Geol. Survey of New Jersey, Pal., vol. iv, p. 849, pl. cxi, figs. 1-15.

Description.—Manus rhombic, its breadth about two-thirds the length, the surface nearly smooth. The outer face is very convex, the greatest convexity being posterior and near the upper or dactylus side; there is a series of four punctures extending backwards from the base of the pollex, and three punctures on the same convex side; *the posterior margin abruptly* falls near the joint, a prominence bearing a group of small tubercles at the summit before the deflection. Inner surface or palm (fig. 1) much less convex than the outer, becoming concave near the lateral margins, nearly smooth, the anterior margin slightly excavated between the bases of the pollex and dactylus, and bordered there with a short row of small tubercles. On the median portion of the palm there are two punctures, marking it off into thirds longitudinally. Lateral margins of the manus acute, closely, finely and regularly crenulate; the lower margin straight, with a row of punctures along the inner side but extremely near the edge, and another less close to the edge outwardly; upper margin deeply curved down posteriorly, produced into a deflexed lobe, and similarly margined with spaced punctures. Pollex about one-half the total length of the palm, curved at the tip, having a blunt median tooth and a crenulated ridge on the grasping face, the lateral edges of which are smooth except at their bases which are crenulated. The dactylus has two contiguous, crenulated ridges along the outer edge.

Carpus is somewhat shorter than the palm, equally convex on both sides, with sharp, crenulated edges like the manus; more swollen distally. The lower distal angle is acute, and there is an oblique groove and a short keel bordered with small tubercles near it on the outer face. The upper proximal angle is produced backward. The inner face has a small distal group of tubercles and some scattered pustules, both usually almost effaced.

Merus subtriangular in section, the upper keel strongly arched, lower keel nearly straight and more strongly serrate, the middle of the very convex outer surface granulose, with two rounded tubercles at the anterior extremity; the opposite or inner face nearly flat. In all specimens preserved with the members in place, the merus is flexed at a right angle with the carpus.

Measurements of manus in millimeters:

	Length	Length exclusive of finger	Width in the middle	Thickness
(a)	—	29	19	9.5
(b)	25	18	11	6

The left cheliped of another specimen measures: Total length of manus, 27, palmar surface (without fingers) 20 mm.; width in middle 13 mm.; greatest length of carpus, measured obliquely 20, or from middle of distal to middle of proximal margin 14 mm.; width in middle 12 mm.; length of merus 13 mm. (No. 10,005 Wagner Free Institute of Science, Matawan formation of Crosswicks, N. J.)

The abrupt deflection of the hind margin of the more convex face of the manus and the downward bend, posteriorly, of its upper margin (as in fig. 1) are characteristic of the species.

Both chelæ of a Lenola individual preserved in one nodule show the right claw to be somewhat the larger. Otherwise the two claws seem to be counterparts. I can find no other difference.

It is an abundant species, known by remains of over one hundred individuals, chiefly the manus only, though sometimes all of the segments of the cheliped are preserved in place; when this is the case, it is usually due to their being imbedded in hard nodules. No remains of the other limbs or the body have been found.

Specimens of the manus and carpus from Bohemia Creek are entirely typical. One broad manus from Brooks estate and one from Post 218, Chesapeake and Delaware Canal, differ in being broader, length of palm 18.3 mm., breadth 14.5 mm. I have seen a few examples of this broad form from New Jersey and am uncertain about its status, whether it is racial or possibly sexual.

Two imperfect chelipeds, not very unlike in size, and in one nodule, were formerly recorded by me as belonging to one individual; but on renewed examination I think them remains of two individuals. The smaller cheliped of *C. mortoni* still remains unknown.

Occurrence.—MATAWAN FORMATION. Post 218, Chesapeake and Delaware Canal, Delaware; Ulmstead Point, Anne Arundel County, Maryland. MONMOUTH FORMATION. Head of Bohemia Creek, Delaware; Brooks estate near Seat Pleasant, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, Academy of Natural Sciences of Philadelphia, Wagner Free Institute of Science.

CALLIANASSA MORTONI var. MARYLANDICA n. var.

Plate XI, Figs. 9, 10

Description.—The manus resembles that of *C. mortoni* by having the inner face (palm) much less convex than the outer. The outer face has a longitudinal series of four punctures running to the base of the pollex, and a series of five to the base of the dactylus; it is contracted near the proximal articulation and has a group of tubercles in the crest before the constriction. The lateral margins of the manus are sharp and crenulated, the margin behind the dactylus being nearly straight, not deflected near the proximal angle as in *C. mortoni.* The pollex is one-third the total length of the manus, and at its base nearly one-third of the width. It has a submedian crenulated ridge and an obtuse median tooth on the grasping margin. The dactylus is not fully exposed, but seems to be somewhat longer than the pollex. The carpus, merus, and ischium do not differ materially from those parts in *C. mortoni.*

Length of hand, exclusive of fingers, 17 mm.; breadth 12 mm.; thickness 6 mm.

This race is separated from *C. mortoni* chiefly on account of the different shape of the outer margin of the hand. In over a hundred individuals seen of that species, the margin is always much more deflected near the proximal angle. The type is a complete cheliped. The example from Seat Pleasant is not fully identified, being imprefect.

Occurrence.—MONMOUTH FORMATION. Brightseat (type locality), Brooks estate near Seat Pleasant, Prince George's County, Maryland; head of Bohemia Creek, Delaware.

Collection.—Maryland Geological Survey.

CALLIANASSA CONRADI Pilsbry

Plate X, Fig. 5

Callianassa conradi Pilsbry, 1901, Proc. Acad. Nat. Sci., Phila., p. 114, pl. i, figs. 8-10.

Callianassa conradi Pilsbry, 1907, in Weller, Geol. Survey of New Jersey, Pal., vol. iv, p. 851, pl. cx, figs. 18-22.

Description.—Manus rhombic, the length of the palm not much exceeding the width, somewhat more convex on the outer than on the inner face, the outer surface neither abruptly nor deeply deflexed near the posterior margin. Surface smoothish, with some tubercles on each side of the slight excavations on both sides of the hand near the commissure between the bases of the fingers; the acute lateral edges of the hand crenulated, as in *C. mortoni,* but the lower edge is not deflexed posteriorly as in that species. Pollex triangular in section, the angles crenulated, the flat grasping face with a short smooth rib near the base, which joins the keel along the outer angle of the pollex. There is no tooth on the pollex.

Length of manus about 30 mm.; exclusive of pollex 18.5; width 16.5; thickness 7.6 mm.

In a few specimens of the paratypic lots the dactylus remains as a short stump only. No carpus or other part is known from the New Jersey localities. Thirteen hands, probably belonging to as many individuals, are before me, the most perfect being one of two in the collection of the Wagner Free Institute of Science.

The manus of *C. conradi* differs from that of *C. mortoni* in being much shorter and broader; more evenly convex on the two sides, the posterior margin of the outer side and the keel along the upper edge are not abruptly deflexed behind; the pollex of *C. conradi* has no median tooth on its grasping face, which is flat with a short smooth ridge and bounded by two crenulate angles, while in *C. mortoni* there is a median tooth, a crenulate ridge on the face, and no crenate angle along the lower inner part of the pollex.

The carpus in a specimen from Brooks estate near Seat Pleasant (pl. A, fig. 4) is more compressed than that of *C. mortoni,* with the proximal end more oblique, and the short, tuberculate carina near the distal angle is much less developed. There is a row of punctures along the distal border.

Two specimens from two localities in Maryland seem referable to this species. That from the Brooks estate consists of a hand, not quite perfect, and the natural mold, which shows also part of the impression of the dactylus, part of the carpus and part of the merus. The specimen from Seat Pleasant is small, a hand with broken fingers. It appears that the

dactylus is decidedly longer than the pollex. The natural mold is also preserved though not perfect. The description is from the type specimen.

Occurrence.—MATAWAN FORMATION. Ulmstead Point, Magothy River, Anne Arundel County. MONMOUTH FORMATION. Brooks estate near Seat Pleasant, and railroad cut west of Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Academy of Natural Sciences of Philadelphia, New Jersey Geological Survey, Wagner Free Institute of Science.

CALLIANASSA CONRADI var. PUNCTIMANUS n. var.

Plate XI, Figs. 4, 5

Description.—The manus is about equally convex on both sides, as in *C. conradi;* sides acute and crenulated, the proximal margin outside very little contracted to the articulation. A longitudinal series of six punctures runs to the base of the dactylus, and another of fewer punctures to base of the pollex. The pollex is broken, but at the base it is triangular in section and found like that of *C. conradi.*

Length of hand 16.4 mm.; breadth 13 mm.; thickness 6 mm.

Type Locality.—Head of Bohemia Creek, Delaware.

It differs from *C. conradi* chiefly in the more numerous punctures of the back of the head. None of the New Jersey individuals of *C. conradi* shows so many punctures.

Occurrence.—MONMOUTH FORMATION. Head of Bohemia Creek, Delaware; Brooks estate near Seat Pleasant, Prince George's County, Maryland.

Collection.—Maryland Geological Survey.

CALLIANASSA CLARKI n. sp.

Plate XI, Figs. 6-8

Description.—The manus is somewhat more convex on its outer face; the lateral edges are pinched into acute, beautifully crenulated keels. The pollex has a low rounded median tooth on the grasping face, thereby differ-

ing from *C. conradi.* The dactylus is irregularly ovate in transverse section, having an acute, finely crenulated cutting edge, even with the outer side, the grasping face within this cutting edge being slightly concave and receding, then rounded, there being no angle along the inner edge of the grasping face. The back of the dactylus has two contiguous angles, one irregularly crenulated, the other finely and regularly crenulated. Laterally, on the outside, the dactylus has a rounded longitudinal rib, and a series of punctures lies in the concavity between this rib and the cutting edge.

Length of palm 10.2 mm.; breadth 7.5 mm.

The carpus (of another individual) is very short and broad, sharp-edged, produced into sharp lateral angles distally; concavity for the condyle of the merus small. Length 8 mm.; width 12.4 mm.

In the type specimen the carpus is largely concealed in a very hard nodule, which could not be further removed without danger to the specimen. The manus has lost a large part of the surface on the exposed side, and the tips of the fingers. Another hand which has lost the fingers has two longitudinal series of punctures, four in each, on the outer side. It is also somewhat broader. Length of palm 13.5 mm.; width 10.8 mm.; thickness 4.7 mm. In this species the convexity of the two sides of the hand is less unequal than in *C. mortoni,* and the lateral edges are nearly straight, not deflected near the proximal angle, as in that species. The shape of the carpus is very different, if I am right in associating the example of this with the manus found at the same place.

Named for Dr. Wm. Bullock Clark, director of the Survey.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal, Delaware.

Collection.—Maryland Geological Survey.

CALLIANASSA sp. undet.

Plate X, Fig. 7

Description.—Two hands from the Chesapeake and Delaware Canal, the palmar aspect of one of them drawn in fig. 6, are probably either the smaller claw of *Callianassa* or from one of the small peræopods. The

lateral edges are acutely carinate but not crenulated. The palmar face is much less convex than the back and both are rather abruptly contracted close to the wrist. The pollex is subtriangular in section. The surface is nearly smooth, without punctures.

The specimen from Post 105: Length of hand with pollex 11.7 mm.; length of palm 9 mm.; breadth about 5 mm.; thickness 2.5 mm.

Specimen from 1½ miles east of the Maryland-Delaware Line: Length with pollex 14 mm.; length of palm 9.8 mm.; breadth 7 mm.

Callianassa clarki was found at Post 105 and *C. mortoni* also occurs elsewhere in the Canal. The hands described above may prove to belong to one of these species. It is a peculiar circumstance that no similar remains have been found in the New Jersey deposits, which have supplied large numbers of the large claws of *Callianassa.*

Occurrence.—MATAWAN FORMATION. One and one-half miles east of the Maryland-Delaware Line on the south side Chesapeake and Delaware Canal; Post 105, Chesapeake and Delaware Canal, Delaware.

Collection.—Maryland Geological Survey.

MOLLUSCA

CLASS CEPHALOPODA

Subclass TETRABRANCHIATA

Order NAUTILOIDEA

Suborder ORTHOCHOANITES

Family NAUTILIDAE

Genus EUTREPHOCERAS Hyatt

[Proc. Am. Phil. Soc. for 1893, 1894, p. 555]

Type.—Nautilus dekayi Morton.

"This genus includes these forms like the type *Eutrephoceras dekayi,* which have globose ananepionic substages, increasing subsequently with great rapidity in all their diameters. The ananepionic and metanepionic substages are highly tachygenic and these shells have very small, and often hardly perceptible and much flattened, umbilical perforations. The siphuncles are subdorsal from the apex through the nepionic stage in some species, in others this position is not maintained, but the siphuncle is generally in later stages near the dorsum and in the ephebic stages it is dorsal of the center.

"The nepionic stage has longitudinal ridges and transverse bands, the former disappearing in adults which are smooth. The form of the whorl in section is nephritic from an early age and changes but little throughout life. The sutures are almost straight, having but slight ventral lobes, broad ventro-lateral saddles, lobes on the umbilical zones and deep lobes in the zone of impression. There are no annular lobes at any stage of development."—Hyatt, 1894.

Etymology: εὐτρέφης, **clasping around.**

EUTREPHOCERAS DEKAYI (Morton)

Plate XIII, Fig. 9

Nautilus dekayi Morton, 1833, Am. Jour. Sci., 1st ser., vol. xxiii, p. 291, pl. viii, fig. 4.

Nautilus dekayi Morton, 1834, Syn. Org. Rem. Cret. Group U. S., p. 33, pl. viii, fig. 4; pl. xiii, fig. 4.

? *Nautilus perlatus* Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 33.

Nautilus dekayi Hall and Meek, 1856, Mem. Am. Acad. Arts and Sci., Boston (n. s.), vol. v, p. 406.

Nautilus dekayi Meek and Hayden, 1856, Proc. Acad. Nat. Sci., Phila., vol. viii, p. 280.

Nautilus dekayi Meek, 1859, Northwest Terr., Rep. Prog. Assinaboia and Saskatchewan Expl. Exped., H. Y. Hind., p. 91, pl. ii, figs. 9, 10.

Nautilus dekayi Conrad, 1860, Jour. Acad. Nat. Sci., Phila., vol. iv, p. 276. (Not *N. dekayi* as figured by Ernest Favre in Moll. Foss. Craie Env. de Lemberg, pl. iii, figs. 1-3.)

Nautilus dekayi Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 25.

Nautilus dekayi Conrad, 1868, Cook's Geol. of New Jersey, p. 731.

Nautilus dekayi Gabb, 1876, Proc. Acad. Nat. Sci., Phila., 1876, p. 277.

Nautilus dekayi Meek, 1876, Rept. Inv. Cret. and Ter. Fossils, Up. Missouri, p. 496, pl. xxvii, figs. 1a-1c.

Nautilus dekayi Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 243, pl. xxxvii, figs. 1-6; pl. xxxviii, figs. 1-4.

Eutrephoceras dekayi Hyatt, 1894, Proc. Am. Phil. Soc., vol. xxxii, p. 555, pl. xiii, figs. 4-8; pl. xiv, fig. 1.

Eutrephoceras dekayi Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 28.

Nautilus dekayi Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 817, pl. c, figs. 1-5.

Description.—" Shell very ventricose, with numerous undulated, transverse striæ; aperture laterally and profoundly expanded."—Morton, 1834.

" Shell subglobose, broadly rounded on the periphery and sides; umbilicus closed; volutions increasing rapidly in size, or more than doubling their diameter each turn, about half as wide again as high, all hidden but the last or outer one; aperture much wider than long, transversely reniform, the lateral extremities being rounded, and the inner side deeply sinuous for the reception of the inner whorls; lip having a wide shallow sinus along the peripheral side, prominently rounded on the lateral margins, and again sinuous near each umbilicus; septa moderately concave, and about sixteen or eighteen to each turn; siphuncle small, located one-fourth to one-third of the distance across toward the periphery, from the

margin of the inner side; surface of adult or medium-sized specimens nearly smooth, or having very obscure lines of growth, crossed by faint traces of longitudinal striæ; on young individuals, or the inner volutions of larger ones, these lines are quite distinct in both directions, and form a very neat, concellated style of ornamentation; internal casts sometimes showing a slender longitudinal line on the center of the periphery.

"The proportions are shown by the following measurements of a young individual: Length 1.84 in., breadth of aperture 1.7 in., diameter of aperture in the direction of the length or greater diameter of the shell 0.72 in. Some imperfect adult individuals before me, too much broken to afford exact measurements, were evidently as much as three times the linear dimensions of that from which the foregoing measurements were taken.

"This common species has been wrongly identified with several foreign forms. D'Orbigny, in his Prodr. de Paléont., expressed the opinion that his own *N. lævigatus,* published in 1846 (not his *N. lævigatus,* 1840) is synonymous with it; also the Indian *N. sphæricus* and *N. orbignyanus* Forbes, and a Chilean form referred by Professor Forbes to *N. lævigatus.* Mr. Blanford, however, considers both of the Indian shells merely varieties of *N. bouchardianus* d'Orbigny, and entirely distinct from *N. dekayi* Morton. I have not the necessary specimens at hand to express any decided opinion in regard to the Indian shells figured by Mr. Blanford all belonging to the one species of *N. bouchardianus;* but I can fully concur with him in the opinion that they are certainly distinct from *N. dekayi* Morton. The latter differs, as stated by Mr. Blanford, in having its umbilicus always filled with a solid shelly kind of columella, formed by the thickening of the lip at its connection with the body of the shell on each side instead of being perforated. *N. dekayi* also has its aperture constantly more transverse, and its siphuncle always nearer the inner side, as may be seen by our fig. 1a, pl. xxvii, which represents very nearly the typical form of the species, as I know from a direct comparison with Dr. Morton's type-specimen, now in the Museum of the Academy of Natural Sciences at Philadelphia, from which type-specimen the foregoing outline-cut showing the position of the siphuncle was drawn.

"It is true that Dr. Morton also referred doubtfully to *N. dekayi* under the provisional name of *N. perlatus,* a more compressed form from Alabama, that would doubtless agree more nearly in the outline of its aperture, and in several other respects, with some of the Indian forms, as well as with the Chilean *N. orbignyanus* Forbes. I have not seen specimens of the Alabama shell showing the position of its siphuncle, but I very much doubt its identity (judging from its form only) with *N. dekayi* proper, as I have seen no tendency among our specimens (that do not differ also in the position of the siphuncle) to assume this more compressed form."—Meek, 1876.

Type Locality.—Monmouth and Burlington counties, New Jersey.

This species occurs in Maryland in the form of well-preserved casts to which portions of the very thin, nacreous shell are still adherent.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, 3 miles south of Oxon Hill, Prince George's County.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Monmouth Formation.* Navesink marl, Red Bank sand, New Jersey. *Ripley Formation. Exogyra costata* zone. *Extreme top of zone,* North Carolina. *Ripley Formation. Exogyra costata* zone, Eufaula, Alabama; Pontotoc, Tippah and Union counties, Mississippi. *Selma Chalk. Exogyra costata* zone, Wilcox County, Tombigbee River and Sumter County, Alabama; east-central Mississippi. *Arrialoor Formation.* Southern India, Aff. *Nautilus bouchardianus* d'Orbigny.

Order AMMONOIDEA

Suborder EXTRASIPHONATA

Family LYTOCERATIDAE

Genus BACULITES Lamarck

[Prodr. de Pal., 1799, p. 80]

Type.—*Baculites vertebralis* Lamarck.

Shell slender, subcylindrical or elongate-conical in the adult stages, more or less compressed laterally, especially upon the posterior side; cross-section ovate-trigonal or subcircular, living chamber large, produced into

Etymology: *Baculus,* a staff.

a ventral crest, the aperture sinuous laterally, convex dorsally and more or less linguiform ventrally; external surface striated with incrementals or even corrugated with simple or nodose costæ; septæ symmetrically divided commonly into six principal lobes and saddles, all of them digitate. *Baculites* like *Pachydiscus* is confined to the Cretaceous, although closely allied ancestral types with less complex sutures have been described from the Jurassic faunas.

BACULITES OVATUS Say

Plate XII, Figs. 2, 3

Baculites ovata Say, 1820, Am. Jour. Sci., 1st ser., vol. ii, p. 41.

Baculites ovata Morton, 1828, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 89, pl. v, figs. 5, 6.

Baculites ovatus Morton, 1830, Am. Jour. Sci., 1st ser., vol. xvii, p. 280; vol. xviii, p. 249, pl. i, figs. 6-8.

Baculites ovatus Morton, 1830, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 196, pl. v, figs. 5, 6; pl. viii, figs. 6-8.

Baculites ovatus Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 42, pl. i, figs. 6-8.

Baculites ovatus Marcou, 1853, Explan. Text to Geol. Map of U. S. and British Prov. N. A., p. 46, pl. vii, fig. 5.

Baculites ovatus Hall and Meek, 1856, Mem. Am. Acad. Arts and Sci., new ser., vol. v, p. 399, pl. v, figs. 1a-1c; pl. vi, figs. 1-7.

Baculites ovatus Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 23.

Baculties ovatus Conrad, 1868, Cook's Geol. of New Jersey, p. 730.

Baculites ovatus White, 1875, U. S. Geol. and Geog. Expl. and Survey, w. 100th Merid., p. 199, pl. 19, figs. 4a-4c, 5a-5c.

Baculites ovatus Meek, 1876, Rept. Inv. Cret. and Ter. Fossils, Up. Missouri, p. 394, pl. xx, figs. 1a-1b, 2a-2d.

Baculites ovatus Whiteaves, 1889, Cont. Can. Pal., vol. i, p. 181.

Baculites ovatus Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 275, pl. xlvi, figs. 3-9.

Baculites ovata Say, 1896, Bull. Am. Pal., vol. i, No. 5, p. 19 (289). (Reprint, Harris.)

Baculites ovatus Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 26.

Baculites ovatus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 821, pl. cix, fig. 5.

Description.—"*B. ovata,* elongated; transverse septa subovate, six-lobed and a smaller one behind; lobes of the superior faces of the septa three on each side, with a minute one between each, dentated at their edges, anterior lobe (nearest the siphuncle) small not sinuous, second lobe

with a single projection each side and sinus at tip, third lobe dilated, with a small sinus each side and more obtuse and profound one at tip, posterior lobe hardly larger than the lateral intermediate ones. Greatest diameter of the transverse section 1.2 in., smaller diameter 0.7 in.; length of the segment about 0.5 in."—Say, 1820.

"Shell attaining a large size, elongated and rather gradually tapering; section ovate, the antisiphonal side being more broadly rounded than the opposite (or very rarely a little flattened ?); aperture of the same form as the transverse section; extension of the lip on the siphonal side long, tapering, and narrowly rounded at the end; lateral sinuses of same deep and about one-half to one-third the greater diameter of the shell; antisiphonal margin of the lip prominently rounded in outline; surface of young and medium-sized specimens generally nearly smooth, while the non-septate part of the adult shell is provided with broad, undefined, obliquely-transverse ridges, or undulations, that arch parallel to the obscure lines of growth, and become nearly or quite obsolete as they approach the siphonal side, on which they are rarely represented by very small, irregular ridges, scarcely distinct from the marks of growth.

"Septa moderately closely arranged, or sometimes a little crowded; siphonal lobe nearly twice as wide as long, and provided with two large terminal widely separated, more or less spreading branches, each of which has sometimes three, and sometimes two, nearly equal, digitate branchlets at the end, and two or three similar lateral ones on the outer side; first lateral sinus about as wide as long, but narrower than the siphonal lobe, and divided at the free end into two short, nearly equal branches, each of which is again less deeply subdivided into about two to three or four sinuous, spreading and digitate branchlets; first lateral lobe oblong-ovate, being longer and narrower than the siphonal lobe, and deeply divided at its end into two very nearly equal branches, with each four to five spreading and digitate subdivisions, in part generally so arranged as to give the main branches a tripartite appearance at their extremities; second lateral sinus of nearly the same size as the first, and, excepting in unimportant details, similarly branched and subdivided; second lateral lobe broader and shorter than the first, and bearing two large, equal tripartite, sinuous,

and digitate terminal branches, and small digitate and simple lateral branchlets; third lateral sinus much smaller than either of the others, with two unequal, short, sinuous and dentate terminal divisions, and a few irregular, short, smaller lateral spurs; dorsal or antisiphonal lobe (ventral lobe of d'Orbigny and others) scarcely as large as one of the terminal branches of the siphonal lobe, longer than wide, with three or four small lateral branches, and normally a trifid free extremity."—Meek, 1876.

Type Locality.—Navesink Hills, New Jersey.

Fragments of this species are rare in the Cretaceous outcropping along the Chesapeake and Delaware Canal in Delaware, and, although it has been reported from Mayland, such occurrences have not been verified.

Occurrence.—MATAWAN FORMATION. Post 218, near Summit Bridge, Chesapeake and Delaware Canal, Delaware.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Woodbury clay, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey; Alabama (Morton). *Pierre* and up into the *Fox Hills* in Dakota, Montana, Colorado and Nebraska.

BACULITES ASPER Morton

Plate XII, Figs. 8, 9

Baculites asper Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 43, pl. i, figs. 12, 13; pl. xiii, fig. 2.

Baculites asper Gabb, 1862, Proc. Acad. Nat. Sci., Phila., for 1861, p. 396, pl. iii, fig. 4.

Baculites asper Meek, 1864, Check List Inv. Fossils, N. A., Cret and Jur., p. 23.

Baculites asper ? Meek, 1876, Rept. Inv. Cret. and Ter. Fossils, Up. Missouri, p. 404, pl. xxxix, figs. 10a-10d.

Baculites asper Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 278, pl. xlvi, figs. 10, 11.

Baculites asper Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 26.

Baculites asper ? Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 823, pl. cix, figs. 6, 7.

Description.—"Transversely suboval, with prominent circumscribed lateral nodes and numerous septa."—Morton, 1834.

Type Locality.—Cahawba, Alabama.

The single fragment collected in Maryland differs from Morton's type in the higher lateral compression and the much less prominent nodes. The sutural characters are similar and, for that reason, they have been united until stronger evidence comes to light for their separation.

Occurrence.—MATAWAN FORMATION. Post 218, Chesapeake and Dela ware Canal, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—MAGOTHY FORMATION. Cliffwood clay, New Jersey. MONMOUTH FORMATION. Navesink marl, New Jersey. EUTAW FORMATION (Tombigbee-sand member). *Exogyra ponderosa* zone, *Mortoniceras* subzone, Columbus, Mississippi; Warrior, Tombigbee and Alabama rivers, Alabama. ? *Fox Hills.* Mouth of Judith River, Montana.

Family DESMOCERATIDAE

Genus PACHYDISCUS Zittel

[Handb. Pal., Ab. I, Bd. II, 1885, p. 466]

Type.—*Pachydiscus wittekindi* (Schlüter).

Large ventricose, heavy-shelled Ammonoids, venter rounded; external surface corrugated with heavy, occasionally nodose ribs, either simple or bifurcating, most vigorous in young forms; sutures complex and finely serrate.

The genus is widespread and abundant in the Cretaceous faunas, but is restricted, apparently, to that epoch.

PACHYDISCUS COMPLEXUS (Hall and Meek) Weller

Ammonites complexus Hall and Meek, 1855, Mem. Am. Acad. Arts and Sci., n. s., vol. v, p. 394, pl. iv, figs. 1a-1f.

Ammonites complexus Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 24.

Ammonites complexus Conrad, 1868, Cook's Geol. of New Jersey, p. 730.

Ammonites complexus Meek, 1876, Rep. Inv. Cret. and Ter. Fossils, Up. Missouri, p. 447, pl. xxiv, figs. 1a-1c.

Ammonites complexus Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 249, pl. xli, figs. 5-7.

Pachydiscus complexus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 819, pl. ci, figs. 3, 4.

Etymology: παχύς, thick; δίσκος, disc.

Description.—"Discoid; umbilicus deep, outer volution covering one-half to two-thirds of the next one within; volutions five or more, ventricose, nearly twice as wide as high; ornamented on the ventral edge by about ten or twelve transverse nodes, slightly elevated, and extending outwards in bifurcating annulations, which cross the back of the shell, uniting again on the oposite side in the same manner. Between these annulations are often other intermediate ones, which are equally prominent on the back of the shell, and die out on the ventral edge.

"These nodes, although existing in the young shell, are scarcely prolonged into annulating ridges, and the back of the shell is smooth, or marked only by the ordinary lines of growth.

"In a young specimen 0.64 in. in diameter, aperture 0.34 in. high, and 0.49 in. wide, septa formed of three symmetrical lobes on each side. Dorsal lobe as deep as the dorsal saddle, but wider, deeply divided at its extremity, and ornamented by two large terminal branches, the outer sides of which are deeply sinuate, a large lateral oblique branch midway between the apex and base of the lobe. Dorsal saddle deeply divided at the extremity into two unequal parts; the upper one again deeply bifurcate, divisions digitate at the extremities; ventral division bifid at the tip; a small branch on each side opposite the extremity of the auxiliary lobe. Superior lateral lobe extremely contracted in the middle by the lateral branches of the saddle; divided towards its extremity into three unequal branches, the terminal one trifid at its extremity, the lateral ones scarcely digitate; two smaller lateral branches towards the base. Lateral saddle in form like the dorsal saddle, with the ventral division larger and bipartite, corresponding to the dorsal division of the other. Inferior lateral lobe shorter than the superior; contracted near the middle, divided into three subequal branches, the lateral ones irregularly digitate, and the terminal one trifid. Ventral saddle oblique, divided by the auxiliary lobe into two branches, which are again bifurcate, with the extremities obtusely bifid. Ventral lobe much smaller and shorter than the inferior lateral lobe, subequally tripartite, with the divisions subdigitate. A small bilobed saddle on the ventral side of the last lobe."—Hall and Meek, 1855.

"Shell compressed-subglobose; periphery broadly rounded; umbilicus rather small and deep; volutions five or more, broader than high, inner ones about half hidden within the dorsal groove of each succeeding turn, ornamented near the umbilicus by a row of small transversely-elongated nodes, which, on the outer whorls of larger specimens, extend outward and bifurcate, so as to form a series of rather distant obscure costæ, which, with others intercalated between, pass over the periphery; surface, so far as known, otherwise smooth, or only marked by obscure lines of growth.

"The largest specimen found (which wants the outer non-septate portion) measures about 1.6 in. in its greatest diameter by about 1 in. in convexity. Adult examples must have been at least 2 in. broad, and may have attained a considerably larger size.

"Septa crowded and complex; siphonal lobe somewhat longer than wide, with its body forming about one-third of its breadth, and bearing three opposite, more or less divided and digitate branches, the two terminal of which are larger than the others and show a tendency to bifurcate; first lateral sinus as long and nearly as wide as the siphonal lobe, with a narrow, somewhat zigzag body, provided with one or two more or less digitate, alternately arranged lateral branchlets, and two much larger unequal, tripartite and digitate terminal branches; first lateral lobe of the same length as the siphonal, with a narrow body and three or four more or less deeply divided and variously digitate lateral branches and a terminal trifid central branch; second lateral sinus a little smaller than the first, but very similar to it in all its details, excepting that its corresponding branches are on opposite sides; second lateral lobe about three-fourths as long and nearly as wide as the first, which it nearly resembles in its branches, excepting that it has one lateral branch less on each side; third lateral sinus shorter than the second and bearing about the same relations to it in its branchings that the second lateral lobe does to the first; third lateral lobe about two-thirds as long and nearly as wide as the second, with three subequal, spreading and digitate terminal branches; fourth lateral sinus less than half as large as the third, oblique and usually tripartite at the end, the branches being nearly simple. Beyond this there

are one or two very small, oblique, nearly simple lobes near the umbilical margin."—Meek, 1876.

Type Locality.—Great bend of the Missouri, below Ft. Pierre, South Dakota.

The species is represented only by fragments, but these retain clearly defined sutures which agree in all essential details with those of Meek's type.

Occurrence.—MATAWAN FORMATION. Camp U & I, Chesapeake and Delaware Canal, Delaware.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Matawan Formation.* Wenonah sand, New Jersey. *Pierre.* Western Interior.

Family COSMOCERATIDAE

Genus SCAPHITES Parkinson

[Organic Remains of a Former World, vol. iii, 1811, p. 145]

Type.—*Scaphites æqualis* Sowerby.

" A fossil concamerated shell, commencing with spiral turns; the last of which, after being elongated, is reflected towards the spiral part."—Parkinson, 1811.

" Shell oval, subcircular or elliptic in general outline, more or less compressed or sometimes gibbous; volutions contiguous or variously embracing in young shells, but last one in the adult more or less deflected and extended from the others, and finally curving backward again; aperture oval or subcircular; lip with a small rim or inflection, but without appendages; septa symmetrical, regularly divided into from four to six lobes and sinuses, nearly always with paired branches, excepting the inner lobe, which is often very small, and sometimes simple; siphonal lobe generally nearly or quite as large as the first lateral; surface merely costate, or also variously nodose; periphery rounded, or, in nodose species, often somewhat flattened and margined on each side (especially of the last turn) by a row of larger nodes, rarely with a central row between."—Meek, 1876.[1]

Etymology: σκαφίτης, a small boat.

[1] Rept. U. S. Geol. Survey, Terr., vol. ix, p. 413.

SCAPHITES HIPPOCREPIS (DeKay) Morton

Ammonites hippocrepis DeKay, 1827, Ann. N. Y. Lyc. Nat. Hist., vol. ii, pp. 273-277, pl. v, fig. 5.

Scaphites cuvieri Morton, 1827, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 109, pl. vii, fig. 1.

Scaphites hippocrepis Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 41, pl. vii, fig. 1. (*S. cuvieri* on plate.)

Scaphites hippocrepis Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 24.

Scaphites hippocrepis Conrad, 1868, Cook's Geol. of New Jersey, p. 730.

Scaphites hippocrepis Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 262, pl. xliv, figs. 8-12.

Scaphites similis Whitfield, 1892, *Ibidem*, p. 267, pl. xliv, figs. 1, 2.

Scaphites hippocrepis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 27.

Scaphites similis Johnson, 1905, *Ibidem*.

Scaphites hippocrepis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 826, pl. cvii, figs. 3-6.

Description.—" Externally smooth, with slight transverse elevations, which in the smaller whorls are very distinct; each whorl envelopes one-half of the internal contiguous whorl, and thus gives to the septum a peculiar lunated appearance. This is supposed to be the last chamber, and a considerable prominence on each side near the outer lip may be considered as analogous to corresponding parts in the *Nautilus,* where the lips fold round in order to be connected with the sides. The septum irregular, with tubercles on its surface, which towards its junction with the sides of the shell assume a branched appearance similar to the divisions of the *Baculites*. The outline of the septum, as may be seen by reference to the figure, is semi-lunated, with the horns produced and somewhat approximated. Thickness one inch. Conjectured diameter of the whole shell two inches."—DeKay, 1828.

Occurrence.—MATAWAN FORMATION. Ulmstead Point, Anne Arundel County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Matawan Formation.*—Merchantville clay, New Jersey.

SCAPHITES CONRADI (Morton) D'Orbigny

Plate XII, Fig. 1

Ammonites conradi Morton, 1834, Synop. Org. Rem. Cret. Group, U. S., p. 39, pl. xvi, figs. 1-3.

? *Scaphites pulcherrimus* Roemer, 1841, Verst. Norddeutschen Kreidegeb., p. 91.

Scaphites conradi d'Orbigny, 1850, Prodr. de Paléont., vol. ii, p. 214.

Ammonites danæ d'Orbigny, 1850, *Ibidem*, p. 213.

Ammonites nebrascensis Owen, 1852, Rept. Iowa, Wisconsin and Minnesota, p. 577, pl. viii, fig. 3; pl. ix, fig. 2.

Scaphites conradi Meek and Hayden, 1857, Proc. Acad. Nat. Sci., Phila., for 1856, p. 281.

Scaphites conradi Meek, 1876, Rept. U. S. Geol. Survey, Territories, vol. ix, p. 430, pl. xxxvi, figs. 2a-2c.

Description.—" Much compressed; one complete volution and part of a second, the smaller being received into and concealed by the larger; five or six rows of tubercles on each side, the outer ones terminating at the peripheral margin, the inner ones at the internal margin of the whorl; tubercles united by subangular, slightly curved costæ. Periphery subconvex, and marked with three or four delicate, longitudinal lines. Septæ innumerable, extremely tortuous and intricate. Largest diameter nearly two inches. Thickness half an inch."—Morton, 1834.

" Shell short-oval-subdiscoid or subcircular in outline, and rather strongly compressed, often attaining a very large size; section of volutions oval, being higher than wide; inner turns closely involute and deeply embracing, generally nearly rounded on the periphery; umbilicus small; deflected part of outer volution very short, and scarcely, or not at all, free at the aperture, which is oval, or with inner side more or less sinuous; surface ornamented with moderate-sized, straight, or sometimes slightly arched costæ, some of which bifurcate once or twice, while shorter ones are occasionally intercalated between the others; costæ all passing nearly straight across the periphery, but often becoming nearly or quite obsolete toward the aperture on the non-septate deflected part of the outer volution—all occupied by the little nodes of the lateral surfaces, of which about six to eight concentric rows may usually be counted on each side of the volutions; nodes of outer row around each margin of the flattened periphery larger than the others, and sometimes compressed.

"Septa rather deeply divided into four principal lobes and as many sinuses on each side of the siphonal lobe, which is nearly oblong in form, about twice as long as wide, and bears three slender digitate main branches on each side, the two terminal of which are a little longer than the others; first lateral sinus as long as the siphonal, and a little wider, provided with three nearly equal, slender, deeply incised and digitate terminal branches and smaller lateral divisions; first lateral lobe as long as the siphonal, and nearly of the same breadth at its free end, where it is provided with two unequal branches, the larger of which (that on the inner side) is subdivided into three digitate branchlets, and the smaller into two, while its slender body supports one or two small, partly digitate, diverging lateral branchlets; second lateral sinus shorter than the first, and scarcely more than half as wide, with two nearly equal bifid and serrated terminal branches, and several short obtuse, irregularly notched, alternating lateral divisions, the sinuses between which are so deep as to give the body a very narrow, zigzag appearance; second lateral lobe a little more than half as long as and wide as the first, and provided with two bifid and digitate terminal branches and one small, nearly or quite simple, diverging lateral branchlet on each side of its slender body; third lateral sinus shorter than the second, but of nearly the same breadth, with a very slender body and two nearly equal, irregularly trifid subdivisions; third lateral lobe rather more than half as long and wide as the second, and very similarly formed; fourth lateral sinus half as long and wide as the third, with two small, irregularly serrated, terminal branches; fourth lateral lobe small, and bifid at the end, the two divisions being very short and bi- or tri-dentate.

"Length of largest example, 6.30 inches; height of same, 5.70 inches; convexity, about 2.70 inches.

" . . . . The specimens of this species figured by Dr. Owen under the name *Ammonites nebrascensis* have the deflected part of the outer volution broken away, in which condition they are, of course undistinguishable from the genus *Ammonites,* as formerly understood in its more comprehensive signification.

"At least in external characters, *S. pulcherrimus* of Roemer, cited doubtfully in the foregoing synonymy, seems to be very closely allied to this species, and I am much inclined to believe that a comparison of specimens may show them to be identical. As Roemer does not figure the septa of his shell, however, and only illustrates the exterior of an imperfect specimen, this question can only be settled by a direct comparison of the shells themselves, or of good figures."—Meek, 1876.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—Ripley Formation. Exogyra costata zone, Prairie Bluff, Alabama. *Fox Hills,* Western Interior.

Genus PLACENTICERAS Meek

[Proc. Amer. Phil. Soc., vol. xi, 1870, p. 429]

Type.—Ammonites placenta DeKay.

"Shell with the very narrow periphery truncated, and often provided with a row of compressed alternating nodes along each margin; volutions each about three-fourths embraced by the next succeeding outer one; septa with the lateral sinuses provided with more or less branched and digitate terminal divisions, umbilicus small or moderate."—Meek, 1876.[1]

PLACENTICERAS PLACENTA (DeKay) Meek

Plate XII A

Ammonites placenta **DeKay, 1828, Ann. N. Y. Lyc. Nat. Hist., vol. ii, p. 278, pl. v, fig. 2.**

Ammonites placenta **Morton, 1830, Am. Jour. Sci., 1st ser., vol. xvii, p. 279; vol. xviii, pl. ii, figs. 1-3.**

Ammonites placenta **Morton, 1830, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 195, pl. v, fig. 4.**

Ammonites placenta **Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 36, pl. ii, figs. 1, 2.**

Ammonites placenta **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 23 (in part).**

Etymology: ***Placenta,*** **a flat cake; κέρας, horn.**

[1] Rept. U. S. Geol. Survey, Terr., vol. ix, p. 463.

Ammonites placenta Conrad, 1868, Cook's Geol. of New Jersey, p. 730.
Placenticeras placenta Meek, 1876, Rept. Inv. Cret. and Ter. Fossils, Up. Missouri, p. 465, pl. xxiv, figs. 2a-2b.
Ammonites (Placenticeras) placenta Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 255, pl. xl; pl. xli, figs. 1, 2.
Placenticeras placenta Hyatt, 1903, *Ibidem*, vol. xliv, p. 211, pl. xxxix, figs. 3-6; pl. xl, figs. 1, 2.
Placenticeras placenta Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 27.
Placenticeras placenta Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 830, pl. civ, fig. 6; pl. cv, fig. 1.

Description.—" Orbicular. Sides diminishing rapidly from the center to the circumference, where they form with each other a very acute angle. The whole external and internal surfaces marked by numerous minute arborescent sutures. Septum sinuous, smooth, except where it united with the points of the shell. Here the septum is furnished with robust branched tubercles, and corresponding depressions for the reception of similar tubercles from the adjoining septum. Siphunculus conspicuous, cylindrical, and funnel-shaped as it approaches the septa. Placed on the margin nearest the center of the whole shell. Thickness 1.8, presumed diameter 6.5."—DeKay, 1828.

" Shell attaining a large size, subdiscoid or lenticular with a deep and distinct umbilicus, the sides of which are gently rounded to the surface of the volution, exposing only a very small portion of each of the inner volutions within it. Dorsum of the shell narrowly rounded and the sides of the volution gradually diverging from its edge to the point of greatest thickness, which is only a short distance outside of the umbilicus. Aperture elongate sagittate; on a cast before me where the volution has a width, from the dorsum to the umbilicus, of 4½ in., the greatest thickness from side to side is just 2 in., the diameter of the shell being 8¾ in. The surface of the shell I have not seen on New Jersey specimens.

" Septa closely interlocking, the lobes and their sinuses being of proportionally small size, but very complicated, varying greatly in this particular with the age of the shell. The interlocking of the septa is so great in the very fine specimen mentioned above that it is impossible satisfactorily to trace any single one entirely across the volution. The lobes in the larger portion of the volution appear to be ten in number exclusive of

the dorsal lobe, and to be somewhat smaller than the corresponding sinuses, except the second and third. The dorsal or siphonal lobe is very wide and deeply forked. The third lateral lobe, or fourth counting the dorsal, is larger than any other, with two large lateral processes and a bifid extremity. The others are generally trifid to the fifth or sixth, beyond this a few of them are bilateral with two divisions on each side; some of the inner ones are long and clavate, with three or four slight projections, while the two inner ones are only serrate on the sides with a perceptibly swollen extremity. There are intermediate lobes between all the principal ones, except the last two, on the largest specimen in hand, but they vary in size and complication according to their position; that dividing the first sinus being about equal in form and size to the seventh lateral lobe. The first sinus is large and broad, each of its main divisions about equal in size to the third sinus."—Whitfield, 1892.

Placenticeras placenta is known within the area under discussion only from the Chesapeake and Delaware Canal, the general area of the type locality. The individuals are all of them from a ferruginous matrix, and though far from perfect the characteristic sutures are sufficiently distinct on all the fragments so that there is no doubt about their determination.

Occurrence.—MATAWAN FORMATION. Posts 249, 208, 105, Chesapeake and Delaware Canal, Delaware; ? Arnold Point, Anne Arundel County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—Magothy Formation.. Cliffwood clay, New Jersey. *Matawan Formation.* Merchantville clay marl, Woodbury clay, Marshalltown clay marl, Wenonah sand, New Jersey. *Pierre.* Western Interior. *? Ripley Formation.* Tennessee (Morton). *Austin Chalk.* Texas, Aff. *Ammonites guadaloupæ* Roemer. *Trichinopoli Formation.* Southern India, Aff. *Ammonites guadaloupæ* Roemer.

Family ENGONOCERATIDAE

Genus SPHENODISCUS Meek

[4th Ann. Rept. U. S. Geol. and Geog. Survey, Terr., 1871, p. 298]

Type.—*Ammonites lenticularis* Owen.

"Shell with periphery cuneate; umbilicus very small; volutions each almost entirely embraced by the succeeding one; septa with the first five or six lateral sinuses provided with only a few short, nearly simple, obtuse divisions; while the others are simple, and usually broadly reniform at the ends."—Meek, 1876.[1]

SPHENODISCUS LOBATUS (Tuomey) Meek

Plate XIII, Fig. 10

Ammonites lobata Tuomey, 1854, Proc. Acad. Nat. Sci., Phila., vol. vii, p. 168.

Ammonites lobatus Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 24.

Ammonites lobatus Conrad, 1868, Cook's Geol. of New Jersey, p. 730.

Sphenodiscus lobatus, Meek, 1876, Rept. Inv. Cret. and Terr. Fossils, Up. Missouri, p. 463.

Ammonites (Sphenodiscus) lenticularis Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 258, pl. xli, figs. 8, 9.

Sphenodiscus lobatus Hyatt, 1903, Mon. U. S. Geol. Survey, vol. xliv, p. 66, pl. vi, figs. 1, 2; pl. vii, figs. 1, 2; pl. ix, figs. 11-13.

Sphenodiscus lobatus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 828, pl. cvi, figs. 1, 2.

Description.—"Shell discoid, smooth, thin towards the circumference; dorsal lobe finely serrate; lateral lobes terminating in large bilobed cells. . . . . This fossil, of which I have only a fragment, resembles *A. placenta* but is distinguished from it by the remarkable cells that terminate the lateral lobe."—Tuomey, 1854.

"A fine specimen . . . . from Ripley group, Lander's Mill, Tippah County, Mississippi, is 111 mm. in diameter. . . . . There are obscure fold-like costæ indicated outside of the greatest transverse diameter, which is nearly central; internally the surface is slightly concave. There are no umbilical shoulders and no flat umbilical zone and umbilical open-

Etymology: σφήν, wedge; δίσκος, disc.

[1] Rept. U. S. Geol. Survey, Terr., vol. ix, p. 463.

ings are shallow. The shell must have been very thick between the volutions, and may have much contracted the opening of the umbilicus. There were twelve lobes and thirteen saddles on the oldest part of the volution. The flat siphonal saddle has a minute saddle in the center and a couple of inflections or marginal lobes on either side of this, and then at the ends two small round saddles. The ventral lobe is very broad and the two arms also broad and obscurely trilobate, each lobe being subdivided by a minute saddle. The first, second and third lobes are broad at top and have an unequal number of small short branches, as if they were derived from the trifid type. They are all probably, however, derived from a bifid type, unless exception may be made for the branches of the ventral lobe.

"The remaining lobes have one large median saddle and an equal number of small lobes as if derived from the bifid type. There is a series from a primitive bifid lobe, the eleventh, and only the twelfth lobe is single. On the right side the twelfth lobe is on the line of involution, whereas on the left side that line is occupied by a saddle. The lobes are very short and broad.

"The first six saddles have broad phylliform bases and the first five are bifid on both sides, being equally divided by a small median lobe, the sixth is transitional and entire; the remaining saddles are of the same type, but so short and broad that they appear to be flattened at the base, and in fact are approximations to that type."—Hyatt, 1903.

Type Localiy.—Noxubee County, Mississippi.

Sphenodiscus lobatus is well characterized by the much compressed lenticular outline. The shell substance is very thin, showing exquisite irridescent colors and is striated with faint and evenly spaced incrementals. All of the individuals upon which the sutures can be traced are referable to the race which Hyatt proposed to isolate under the name *Beecheri,* characterized by a slightly higher complexity of the suture line. The differences are no greater, however, than those exhibited by other species, and as they have, apparently, neither geographic nor stratigraphic significance, there seems to be no reason for recognizing them.

The species occurs quite abundantly throughout Prince George's County, but it is exceedingly difficult to remove the soft and crumbly

shells from their matrices without injuring them. The form has been confused in the synonymies with *S. lenticularis* Owen, from the Fox Hills Group of the Upper Missouri. The east coast form differs from that of the interior by the greater complexity of the sutures, particularly the saddles.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Friendly, 1 mile west of Friendly, McNeys Corners, Prince George's County.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Magothy Formation.* Cliffwood clay, New Jersey. *Matawan Formation.* Merchantville clay marl, Woodbury clay, Marshalltown clay marl, Wenonah sand, New Jersey. *Peedee Sand.* North and South Carolina. *Ripley Formation. Exogyra costata* zone. *Extreme top of zone,* Lowndes, Tippah and Union counties, Mississippi. *Selma Chalk. Exogyra costata* zone, Starkville, Mississippi. *Fox Hills.* Western Interior, Aff. *Sphenodiscus lenticularis.*

Family PRIONOTROPIDAE

Genus MORTONICERAS Meek

[Inv. Pal., vol. ix, 1876, p. 448]

Type.—*Ammonites vespertinus* Morton. (= *A. texanus* Roemer.)

" Shell discoid; periphery with a simple, low, central keel, and a more or less defined sulcus on each side of it, the sulci being generally each margined externally by a row of compressed nodes; umbilicus wide; volutions narrow; slightly embracing, and ornamented by regular, simple, straight, tuberculated costæ. Septa in the typical species with three lateral lobes on each side, the first one being longer than the siphonal lobe, with tripartite extremity, the terminal division being deeply bifid; the second and third lobes much smaller and more or less tripartite or dentate; first and second lateral sinuses more or less nearly equally bipartite or bilobate at the ends. Shells of this genus will be distinguished from the restricted genus *Ammonites* by their always single peripheral keel,

Etymology: " Dedicated to Dr. Samuel George Morton, deceased."

straighter and differently tuberculated costæ, and differences in the forms and proportions of its septa, lobes and sinus."—Meek, 1876.

MORTONICERAS DELAWARENSIS (Morton)

Plate XII, Fig. 7

Ammonites delawarensis **Morton, 1830, Am. Jour. Sci., 1st ser., vol. xviii, pl. ii, fig. 4.**

Ammonites vanuxemi **Morton, 1830, *Ibidem*, pl. iii, figs. 3, 4.**

Ammonites delawarensis **Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 37, pl. ii, fig. 5.**

Ammonites vanuxemi **Morton, 1834, *Ibidem*, p. 38, pl. ii, figs. 3, 4.**

Ammonites delawarensis **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 24.**

Ammonites delawarensis **Conrad, 1868, Cook's Geol. of New Jersey, p. 730.**

Ammonites delawarensis **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 252, pl. xlii, figs. 6-9; pl. xliii, figs. 1, 2.**

Ammonites vanuxemi **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 253, pl. xlii, figs. 1-5.**

Ammonites delawarensis **Roberts, 1895, Johns Hopkins Univ. Circ., vol. xv, No. 121, p. 16.**

Ammonites delawarensis **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 27.**

Ammonites vanuxemi **Johnson, 1905, *Ibidem*.**

Mortoniceras delawarensis **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 837, pl. ciii, fig. 1; pl. civ, figs. 1-5.**

Description.—"Volutions uncertain; each whorl furnished with elevated transverse ridges, which bifurcate about half-way across and terminate in prominent tubercles on the margin; ridges marked by three or four conspicuous nodes; back between the tubercles convex; probable diameter from 8 to 12 in."—Morton, 1834.

"The shell seems to have been a very variable one, especially so when different periods of growth are considered. The young form was described by Dr. Morton as *A. vanuxemi,* in which condition it is somewhat discoid, with a moderately large umbilicus with vertical sides; about one-half only of the volution being embraced by the succeeding one; the narrow dorsum being triply keeled; the marginal keels being formed of obliquely elongated nodes formed by the extremities of the numerous, rounded costæ which cross the sides of the volution. A row of nodes marks the ends of the costæ along the margin of the umbilicus, and three other lines occur

at nearly equal distances apart, between the first and the marginal row, which forms the lateral keel. When more advanced in growth the sides become rounded and convex; the dorsum proportionally wider and less distinctly keeled; the volutions somewhat more involved within the outer one, which gives a correspondingly narrower umbilicus in proportion to the entire diameter; the ridges crossing the sides are proportionally less elevated and the nodes less conspicuous. In a large cast sent me, as one of the type specimens, from the Academy of Natural Sciences, Philadelphia, the thickness at the edge of the umbilicus is $2\frac{3}{8}$ in., when the width of the volution is $3\frac{1}{4}$ in. A small specimen, apparently entirely uncompressed, presents a width on the side of the volution of three-eighths of an inch, and a diameter of one-sixteenth less at the edge of the umbilicus. The same features of the surface are present on both specimens, differing only in degree. The septa are marked by three lobes and an imperfect fourth one on the inner margin, and by three sinuses. The dorsal lobe has a pair of short, principal, digitate branches, with several small digitations along its sides. First lateral lobe moderately large, with four principal, much serrated branches, and two or more minor ones on the neck. The second lateral is irregularly branched, having two or three divisions, and the one bordering the umbilicus has the margin simply undulated. The first sinus is very large and divided in the middle by a long, slender, digitate, minor lobe, which extends nearly or quite half the length of the dorsal lobe. The second sinus is not more than two-thirds the size of the first and far less distinctly divided. The small umbilical sinus has the margin rather deeply undulated only. The margins of the sinuses are clavately undulated and those of the lobes more sharply serrated; the number and complication of these features varying, of course, with the size and age of the shell. In the young specimens . . . . the complications of the lobes and sinuses are more simple, although all the features are present." —Whitfield, 1892.

Type Locality.—Lower beds of Chesapeake and Delaware Canal.

As *Mortoniceras delawarensis* is represented in Maryland by fragments, there is little hope of determining its relationship to *M. vanuxemi* Morton. Both forms occur in the Merchantville clay marl of the Matawan of New

Jersey, and Weller believed that the differences were due to age characters rather than specific. Whitfield's position was contradictory, but his final opinion seemed to be in favor of the separation of the forms, because of the higher lateral compression and the finer, less elevated transverse ridges of the *M. vanuxemi.* These characters he believed to be present in the *M. vanuxemi* at every stage of growth, and much more conspicuous than in *M. delawarensis* of the same size. The flattened center with the raised evenly rounded median keel margined laterally by prominent tubercles, the outposts of the more or less irregularly bifurcating transverse ribs and the serrated sutures, serve to diagnose this species even when in a fragmentary condition.

Occurrence.—MATAWAN FORMATION. Near Summit Bridge, Chesapeake and Delaware Canal, Post 105, Chesapeake and Delaware Canal, Delaware; Ulmstead Point, three-quarters of a mile southeast of Ulmstead Point, Anne Arundel County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—Matawan Formation. Merchantville clay marl, New Jersey.

Subclass DIBRANCHIATA

Order BELEMNOIDEA

Family BELEMNITIDAE deBlainville

Genus BELEMNITELLA d'Orbigny

[Pal. Franc. Terr. Crét. Céphalopodes, vol. 1, 1840, p. 59]

Type.—Belemnites paxillosus Lamarck = *Belemnitella mucronatus* Schlottheim.

"Guard cylindrical or more or less clavate, provided with a deep conical cavity in the anterior end for the reception of the phragmocone, and usually more or less pointed behind; wall of the conical cavity divided by an open, longitudinal linear slit down the ventral side; surface ornamented on the ventral side by distinct vascular (?) markings, and having

Etymology: Diminutive of βέλεμνον, **a dart.**

on the dorsal side a broad flattened ridge; phragmocone nacreous, and provided with a single dorsal ridge and a ventral process, and often with a minute bulb at the apex."—Meek, 1876.[1]

The genus is restricted in its distribution to the Middle and Upper Mesozoic.

BELEMNITELLA AMERICANA (Morton)

Plate XII, Figs. 4-6

Belemnites subconicus Morton, 1828, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 91, pl. v, fig. 7. (Not *B. subconicus* Lam.)

Belemnites americanus Morton, 1830, Am. Jour. Sci., 1st ser., vol. xvii, p. 281; vol. xviii, pl. i, figs. 1-3.

Belemnites americanus Morton, 1830, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 190, pl. viii, figs. 1-3.

Belemnites americanus Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 34, pl. i, figs. 1-3a.

Belemnitella americana Emmons., 1858, Rept. N. C. Geol. Survey, p. 246, fig. 101.

Belemnitella paxillosa Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 26.

Belemnitella mucronata Conrad, 1868, Cook's Geol. of New Jersey, p. 375, figure; p. 731.

Belemnitella paxillosa Conrad, 1868, *Ibidem*, p. 731.

Belemnitella americana Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 280, pl. xlvii, figs. 1-11.

Belemnitella americana Roberts, 1895, Johns Hopkins Univ. Circ., vol. xv, No. 121, pp. 16, 17.

Belemnitella americana Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 28.

Belemnitella americana Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 839, pl. cix, figs. 1-4.

Description.—"Stylet or guard rather large, solid and heavy, often becoming thickened with age so as to be proportionally much larger in diameter as compared with smaller individuals. Specimens varying from 3 in. to nearly 4 in. in length below the base of the slit, the larger ones evidently having a length of fully 6 in. from the lower extremity to the top of the internal cavity or conotheca. General form triangularly cylindrical in the upper part, becoming flattened on the ventral side in the

[1] Rept. U. S. Geol. Survey, Terr., vol. ix, p. 501.

lower port, with frequently a slight mucronate extremity, which when broken generally shows a slight central perforation, as do many of those which are destitute of this pointed extremity. In many old examples the extremity is solid . . . . while in the largest individual which I have observed from New Jersey . . . . there is yet a slight perforation. I have never seen the mucronate point exceeding one-sixth of an inch in length. The upper end of the stylet or guard, from about the base of the internal cavity, gradually expands upward and becomes very thin on the edge, and the inner surface of the wall often bears the marks of the transverse septa of the phragmocone. At about the base of the cavity the external diameter is less than below, and in some examples the lower portion is considerably expanded as in the . . . . typical specimen of Dr. Morton's var. A *B. suffusiformis*, while in others there is almost a regular decrease downward to near the extremity, which is usually obtusely rounded except for the mucronate point occasionally seen. Very young specimens often present a long slender extremity. On the ventral side, the slit extends fully one-third of the length of the shell, where the walls of the upper portion are preserved to near their full length, which is seldom the case; its width in the lower half often being little more than the thickness of heavy writing paper. The flattening of this side of the stylet commences near the base of the slit and extends almost to the lower extremity of the guard. On the dorsal side there is a raised elongate lanceolate area, which is narrow and prominently angular in the upper part of the body, but is flattened or simple depressed convex on the surface and gradually widens below the base of the slit so as to become from half the entire width of the shell to almost its equal in width, but produces a slight angularity on this side throughout the entire length. The entire surface is usually much roughened when not worn, the roughening being greatest on the ventral side, while laterally this roughening produces vascular lines running obliquely backward in crossing from the ventral to the dorsal surfaces, and on the raised lanceolate area of the dorsal surface the markings are finer and arranged so as to produce longitudinal lines, or interrupted striæ. . . . .

"The phragmocone is seldom seen showing the lines of septa, and when seen they appear to be only external or marginal. Among the few bearing the lines which I have examined none have shown the septa extending across. This body is rather abruptly obconical, and is just a little ovate in transverse section, one side being a very little angular and with a raised, rounded longitudinal ridge, corresponding to the angularity of the solid fissure of the guard being regularly curved, as is the inside of the cavity itself. The lines of septa are very numerous and closely arranged near the pointed end, but gradually and regularly increase in distance from each other, so that where the diameter of the cone reaches five-eights of an inch, the septæ are fully a twelfth of an inch apart. In their direction across the cone they are nearly straight, except on the angularity, where they are slightly advanced. The position of the siphuncle I have not observed.

"The substance of the guard is quite dense, and is transversely fibrous, the fibers being very slightly directed downward from the initial line, which is never quite central but is usually placed considerably nearest to the fissured margin of the guard."—Whitfield, 1892.

Type Locality.—Arneytown, New Jersey.

Belemnitella americana is known in Maryland only from Bohemia Creek, Cecil County. It is perhaps the most valuable horizon marker of the Cretaceous, since it has never been reported from either above or below the Monmouth and is determinable from the merest fragment.

Occurrence.—MONMOUTH FORMATION. Briar Point, Chesapeake and Delaware Canal, Delaware; 1 mile south of Bohemia Mills, head of Bohemia Creek, Bohemia Mills, 1 mile southwest of Bohemia Mills, Cecil County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey. *Peedee Sand.* North and South Carolina. *Selma. Exogyra costata* zone, east-central Mississippi, Lee and Tippah counties, Mississippi; Wilcox and Sumter counties, Warrior and Tombigbee rivers, Alabama. *Senonian.* Europe, Aff. *Belemnitella mucronata.*

CLASS GASTROPODA
Order OPISTHOBRANCHIATA
Suborder TECTIBRANCHIATA
Family ACTEONIDAE
Genus ACTEON Montfort
[Conch. Syst., vol. ii, 1810, p. 314]

Type.—*Voluta tornœalis* Gmelin.

Shell thin, ovate; spire usually prominent, acutely tapering; nucleus rather small, twisted, heterostrophous; principal sculpture spiral; aperture entire, elongate; rounded anteriorly; columella furnished with a single, slightly oblique plication; umbilicus imperforate.

The genus is indicated in the Triassic and reached its maximum development in the Eocene, though it persisted with diminished prominence through the later Tertiary and to the present day. The living species, though comparatively few in number, have a wide geographic range.

A. Whorls very broadly convex; spiral sculpture uniform in character over the entire external surface........................*Acteon linteus*
B. Whorls flattened laterally; cylindrical; exceedingly slender; spiral sculpture evanescent on the posterior portion of the whorls. *Acteon gabbana*

ACTEON LINTEUS Conrad

Plate XVIII, Figs. 3, 4

Solidulus linteus Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iii, p. 334, pl. xxxv, fig. 10.

Description.—" Elliptical, with very numerous close revolving lines, most distinct on the inferior half; interstices regularly and elegantly striated transversely. A beautiful species, but the specimen much distorted, which I have endeavored in the figure to restore to something of its original shape."—Conrad, 1858.

Etymology: 'Ικταίον, dwelling on the coast.

Type Locality.—Owl Creek, Tippah County, Mississippi.

Shell ovate to subcylindrical in outline; height of aperture more than one-half the total altitude; whorls five or six in number, minutely tabulated, feebly inflated, increasing in size with a moderate degree of rapidity; external surface sculptured with fine, regularly spaced, squarely channelled, linear sulci, seven or eight in number upon the penultima, and between twenty-five and thirty on the body; inter-areas low and flattened, more than double the width of the sulci; fortuitous secondary spirals developed midway between the primaries on the medial portion of the ultima; sulci microscopically punctated by the incrementals; suture lines distinct, impressed; body whorl evenly rounded at the base; aperture rather narrow; outer lip almost vertical, patulous anteriorly; inner lip constricted at the base of the ultima; columella reinforced near its extremity and bearing a single very oblique plication, which almost or quite evanesces before reaching the aperture; parietal wall entirely free from callous.

Dimensions (figured specimen).—Altitude 14 mm., maximum diameter 5.7 mm.

The Maryland species is quite certainly identical with Conrad's *Solidulus linteus* from the Ripley of Tippah County, in spite of the dissimilarity in the two figures. Conrad's figure is a reconstruction made from a badly crushed individual with the aid of his imagination, and is inaccurate in the relative proportions of spire and body whorl and in the outline of the aperture.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Ripley Formation. Exogyra costata* zone, Owl Creek, Tippah County, Mississippi.

ACTEON GABBANA Whitfield

Actæonina biplicata Gabb, 1861, Proc. Acad. Nat. Sci., Phila., 1860, p. 93, pl. ii, fig. 13. (Not *Actæon biplicata* d'Orbigny.)

Actæon biplicata Meek, 1876, Hayden, Rept. U. S. Geol. Survey, Terr., vol. ix, pp. 281, 282.

Actæon gabbana Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 156, pl. xix, figs. 13 (?), 23-25.

Actæon gabbana Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.

Actæon gabbana Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 807 *(ex parte)*.

Description.—" Shell of medium size, elongate ovate or subcylindrical in outline, spire moderately elevated, entire length and number of volutions unknown. Body volution cylindrical in the upper half, obtusely rounded below. Aperture narrow, pointed and very contracted above and rounded below, about four-fifths as long as the length of the body volution, measured on the same side. Columella slightly twisted below and marked by a single tooth near the base as determined by the groove showing on the cast. Surface of the shell marked by fine spiral lines, the number undeterminable from the specimens examined. . . . . There appears to have been some confusion in the author's mind in regard to the specific relations of this shell, when the name *Actæonina biplicata* was applied; and also subsequently, as he refers it to a species described by Meek and Hayden from Nebraska. These latter gentlemen, however, disclaim the responsibility of the name, and as none such appears in any of their works we can only conclude that Mr. Gabb was in some way confused, as suggested by Mr. Meek in his Invert. Paleont. of the Territories, that Mr. Gabb intended to refer it to *A. attenuata;* but it certainly is a very distinct species and can never have had so elevated a spire as that one. As the name *A. biplicata* has been previously used by d'Orbigny for a very distinct species, and as this one appears to be a true *Actæon,* I see no way to avoid a change of name in this case, and therefore propose the name *Actæon gabbana* as a substitute for that used by Mr. Gabb."—Whitfield, 1892.

Type Locality.—Tinton Falls, New Jersey.

Shell small, cylindrical, exceedingly slender; whorls flattened laterally, minutely tabulated posteriorly; spiral sculpture microscopically fine, irregular and evanescent on the posterior portion of the whorl, the sulci increasingly deeper and wider toward the anterior extremity; suture lines impressed.

Actæon gabbana Whitfield is smaller than *A. linteus* Conrad, more slender, and more cylindrical, with a fainter and more irregular spiral sculpture.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

Family RINGICULIDAE

Genus RINGICULA Deshayes

[Hist. des Animaux sans Vertèbres, 2d ed., 1838, vol. viii, p. 342]

Type.—*Auricula ringens* Lamarck.

Shell small, ventricose, spire relatively short; nucleus heterostrophous; surface of shell smooth or spirally striate; aperture narrow, parallel to the axis of the shell, dilated and more or less emarginate anteriorly; outer lip thickened and reflected, smooth or finely plicate within; columella excavated, calloused, furnished posteriorly as a rule with a strong tubercular denticle and anteriorly with two prominent, transverse plaits.

The genus has been noted in the Cretaceous deposits of Europe and India as well as in those of North America. Some seventy species are reported from the various Tertiary horizons, and about thirty-five from the temperate and tropical waters of to-day.

RINGICULA CLARKI n. sp.

Plate XVIII, Figs. 1, 2

Description.—Shell rather large for the genus, ovate in outline; spire moderately high, its altitude a little less than half that of the entire shell; whorls five or six in number, subtrapezoidal, obscurely shouldered; external surface highly polished, sculptured merely with two or three feebly impressed spirals in front of the sutures of the later whorls and

Etymology: *Ringor*, to show the teeth. A probable allusion to the prominent tooth borne upon the posterior portion of the labium.

an equal number near the base of the body; faint incremental striations also discernible under magnification; suture lines impressed; body whorl broadly and feebly convex, rather abruptly constricted at the base; aperture more than half as high as the entire shell, broader and somewhat patulous anteriorly; outer lip strongly varicose, the varix produced backwards almost or quite to the suture line; inner lip arcuate, strongly constricted at the base of the body, heavily calloused, bearing two conspicuous folds. a horizontal plait at the base and an oblique marginal plait not quite so prominent as the one behind it; parietal wash heavy, its margin sharply defined and not reaching the posterior commissure; base deeply emarginate.

Dimensions.—Altitude 10.2 mm., maximum diameter 7 mm.

Type Locality.—Brightseat, Prince George's County.

The form is well characterized by its squat outline, conspicuously varicose outer lip and prominent columellar folds.

This interesting and abundant species is named in honor of Prof. William Bullock Clark of Johns Hopkins University, and the head of the Geological Survey of Maryland.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, and Friendly, Prince George's County.

Collection.—Maryland Geological Survey.

Genus CINULIA Gray

[Syn. Brit. Mus., 1840, pp. 62, 90]

Type.—*Auricula globulosa* Deshayes.

Shell more or less globose; spire very low, sometimes abruptly attenuated; external surface spirally lirate or striate; aperture narrow and somewhat arcuate; margin of outer lip much thickened but smooth within; columella very short, bearing a single, anteriorly produced plication; anterior emargination obsolete.

Cinulia is separated from *Avellana* by the development of a single columellar plication instead of two, three or four, by the uniform absence of denticles upon the inner surface of the labrum, and by the obsolete anterior notch.

The genus is restricted in its known distribution to the Cretaceous.

CINULIA NATICOIDES (Gabb) Meek

Actæonia naticoides **Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 299, pl. xlviii, fig. 2.**

Cinulia ? naticoides **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 16.**

Cinulia ? naticoides **Conrad, 1868, Cook's Geol. of New Jersey, p. 728.**

Actæonina naticoides **Conrad, 1868,** ***Ibidem.***

Cinulia (Oligoptycha) naticoides **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 161, pl. xix, figs. 28-30.**

Cinulia naticoides **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.**

Cinulia naticoides **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 811, pl. xcix, figs. 12, 13.**

Description.—" Shell globose; whorls three or four; spire very slightly elevated; surface marked by numerous revolving lines. Locality and position: From the marl of New Jersey. There are two specimens in the Academy's collection; one from Burlington County, New Jersey; the locality of the other is not known. One specimen in my own collection is from Mullica Hill."—Gabb, 1860.

Type Locality.—Mullica Hill, New Jersey.

Shell small, globose; spire evolute, but very much depressed; aperture a little more than two-thirds the total altitude of the shell; nuclear characters lost; entire external surface sculptured with low, flattened fillets, approximately twenty-five in number upon the ultima, uniform in size and spacing, and separated by squarely channelled, sublinear sulci; aperture loop-shaped, angulated behind, narrow but well rounded in front; outer lip arcuate; inner lip conforming to the outline of the body, bearing near its anterior extremity a single oblique plication.

The species is remarkable for its globose outline and uniform close-set sculpture.

Occurrence.—MATAWAN FORMATION. Three-quarters of a mile below Ulmstead Point, Anne Arundel County. MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

Genus AVELLANA D'Orbigny

[Pal. Franc., Terr. Crét., t. ii, Gastropodes, 1842, pp. 131, 132]

Type.—*Avellana incrassata* Mantell.

"Shell globose, ventricose, low, sculptured with spiral striations or punctate grooves. Spire very short, aperture semi-lunar, compressed and arcuate without an anterior emargination. Lip very thick, often reflected and prominent without, almost always dentate within. Columellar margin furnished with three or four teeth, the anterior of which is the strongest."—Translated from d'Orbigny, 1842.

The genus differs from *Ringicula* in the development of a well defined spiral sculpture, the number and disposition of the columellar plaits and in the entire absence of an anterior canal.

Avellana has a wide distribution in strata of Cretaceous age, but it has not been reported either from the older Mesozoic or from the Tertiaries.

A. Altitude of adult shell exceeding 18 mm................*Avellana bullata*
B. Altitude of adult shell not exceeding 18 mm.
1. Diameter of adult shell less than two-thirds of its altitude. *Avellana costata*
2. Diameter of adult shell more than two-thirds of its altitude.
a. Spirals on body whorl exceeding 15 in number..*Avellana pinguis*
b. Spirals on body whorl not exceeding 15 in number. *Avellana lintoni*

AVELLANA BULLATA (Morton) Whitfield

***Tornitella ? bullata* Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 48, pl. v, fig. 3.**

***Solidula ? bullata* Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 17.**

***Solidula bullata* Conrad, 1868, Cook's Geol. of New Jersey, p. 728.**

***Avellana bullata* Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 163, pl. xx, figs. 1-4.**

***Avellana bullata* Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.**

***Avellana bullata* Weller, 1907, Geol. Survey of New Jersey, vol. iv, p. 808, pl. xcix, figs. 9-11.**

Description.—"Ovoidal, ventricose, with numerous transverse striæ. Length, about 1 in."—Morton, 1834.

Type Locality.—New Jersey.

Etymology: *Avellana*, filbert.

"Shell large for the genus, attaining fully an inch in length; very globose, the diameter being nearly as great as the height, at least equalling seven-eighths of the height. Spire low and rounded, and the base only slightly more pointed. Volutions between three and four in number, the outer half of the last one more abruptly deflected downward at the suture than the preceding ones, but again elevated near the aperture. Aperture narrow, pointed above and widest below and rounded; the length equal to about four-fifths of the entire length of the shell; columellar margin thickened and marked by horizontal ridges on the upper two-thirds of its length, and by two very strong, ridge-like teeth or plications below the middle, the upper of which is the stronger. Base and outer lip slightly thickened. Surface of the shell, as shown on the cast, marked by fine spiral lines, and by transverse lines of growth. Of the spiral lines, about thirty may be counted on the outer half of the body whorl of the larger individual, those near the base being coarser than those above, but gradually becoming fainter in strength. On one of Dr. Morton's types the transverse lines are regular and but little less strongly marked than the spiral lines, so that the surface under a glass looks to be cut up into small nearly equal solid nodes."—Whitfield, 1885.

The species is represented within the area under discussion merely by water-worn casts which have, however, preserved enough of the diagnostic features to make their determination certain.

Avellana bullata (Morton) is much larger and more globose than any of the co-existent members of the genus.

Occurrence.—MATAWAN FORMATION. Old water-filled marl pit on east bank of cove near Post 236, and opposite Post 201, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey. *Monmouth Formation.* ? Navesink marl, New Jersey.

AVELLANA COSTATA (Johnson) Weller

Cinulia costata Johnson, 1898, Ann. Rept. Geol. Survey of New Jersey, 1897, p. 264 (name only).
Cinulia costata Johnson, 1898, Proc. Acad. Nat. Sci., Phila., p. 462, text fig. 1.
Cinulia costata Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.
Avellana costata Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 810, pl. xcix, fig. 21.

Description.—"Shell with four whorls, spire prominent, body whorl with from twelve to thirteen revolving grooves, which form an equal number of smooth, flat, revolving costæ; these average about double the width of the grooves. In one specimen the third and fifth costæ from the suture are almost twice the width of the others, and the two lower costæ divided by a minute, impressed line. The first spiral whorl has six, and the second five revolving grooves. Apical whorl smooth, suture deeply impressed. Aperture narrow, oblique, lip broad, thick and crenulated on the inner margin with eight small teeth-like projections, and extending to the suture where it joins the callus of the peristome, which is continuous to the base of the columella; base with two oblique folds, above which is a prominent fold or plate extending at almost right angles to the columella; between this and the posterior angle of the aperture is a small, tooth-like projection. Altitude 4 mm., diameter 2½ mm."—Johnson, 1898.

Type Locality.—Mount Laurel, New Jersey.

Avellana costata (Johnson) is restricted in its Maryland distribution to the Monmouth where it is associated with *Ringicula clarki,* which it closely resembles in size and contour. The development of a well defined though feeble spiral sculpture over the entire external surface of the former readily separates it from the *Ringicula,* which is, to be sure, faintly lineated spirally in front of the posterior suture and near the base, but not at all upon the medial portion of the body.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Matawan Formation.* ? Woodbury clay, New Jersey.

AVELLANA PINGUIS n. sp.

Plate XVIII, Figs. 5, 6

Description.—Shell moderately large for the genus, ovate and squat in outline; whorls broadly rounded, increasing rather rapidly in size, approximately six in number; apex broken away so that exact number is indeterminate and apical characters are lost; external surface sculptured with feebly impressed linear sulci, eight or nine in number upon the penultima, eighteen or twenty upon the ultima; suture lines distinct, impressed; aperture rather narrow, pyriform; outer lip imperfect, feebly arcuate, apparently, and slightly patulous anteriorly; inner lip heavily reinforced, bearing near its anterior extremity two strongly elevated, oblique plications and half-way between them and the posterior commissure a third prominent plication set normal to the columella; parietal wall thickly calloused from the posterior commissure to the anterior emargination, the outer margin of the wash parallel to the outer lip posteriorly, expanding near the horizontal fold; anterior notch moderately deep.

Dimensions.—Altitude 11.8 mm., maximum diameter 9.8 mm.

This species is most readily separable from *A. lintoni* n. sp. by the much more numerous spiral lirations. From *A. costata* (Johnson) it is distinguished not only by its larger size, but also by its stouter and more rounded outline. It is rare even at the single locality at which it is represented.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

AVELLANA LINTONI n. sp.

Plate XVIII, Fig. 7

Description.—Shell rather stout, ovate, scalariform in outline in the cast; whorls five or six in number, narrowly tabulated posteriorly in the cast, those of the spire straight-sided, the body whorl evenly but feebly inflated, abruptly constricted at the base: external surface decorticated, leaving no trace of sculpture excepting at the labial varix; suture lines

impressed; aperture rather narrow, outer lip strongly varicose, the varix produced backward upon the penultima; outer base of varix marked by a series of shallow, parallel sulcations, ten or twelve in number, the relics of the impressed spiral sculpture; inner lip probably heavily calloused, bearing at the base two prominent oblique plications, and, half-way between them and the posterior commissure, a less prominnent horizontal fold; base emarginate.

Dimensions.—Altitude 12.6 mm., maximum diameter 10.7 mm.

Type Locality.—Two miles southwest of Oxon Hill, Prince George's County.

This species differs from the preceding in the lesser number of spiral lirations and the greater angularity. *Avellana costata* (Johnson) is much smaller and more slender, both absolutely and relatively.

Occurrence.—MONMOUTH FORMATION. Brightseat, and 2 miles southwest of Oxon Hill, Prince George's County.

Collection.—Maryland Geological Survey.

Family AKERATIDAE

Genus HAMINEA Gray

[Am. Mag. Nat. Hist., vol. xx, 1847, p. 268]

Type.—*Bulla hydatis* Linné.

Shell very thin, inflated, oval or subcylindrical in outline; spire involute. External surface finely striated. Aperture as long as the shell, narrow posteriorly, broader and somewhat patulous in front. Outer lip thin, sharp, nearly vertical in the medial portion. Columella thin, not glazed or plicate.

Haminea has been an inconspicuous element in the molluscan faunas from the Cretaceous to the Recent.

A. Body whorl medially inflated, basally constricted.......*Haminea mortoni*
B. Body whorl cylindrical in outline....................*Haminea cylindrica*

Etymology: *Hamus*, a hook. A name suggested by the outline of the aperture.

HAMINEA MORTONI (Forbes) Weller

Bulla mortoni Forbes, 1845, Quart. Jour. Geol. Soc., London, vol. i, p. 63, text fig. a.

Bulla mortoni Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 16.

Solidula mortoni Conrad, 1868, Cook's Geol. of New Jersey, p. 728.

Bulla mortoni Conrad, 1868, *Ibidem*.

Bulla mortoni Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 165, pl. xx, figs. 7-9.

Bulla conica Whitfield, 1892, *Ibidem*, p. 189, pl. xxiii, figs. 12, 13.

Bulla mortoni Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.

Haminea mortoni Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 812, pl. xcix, figs. 14, 15.

Description.—" (Cast.) Ovate, inflated, resembling in form *B. hydatis*, spire concealed, surface spirally furrowed, the furrows bearing traces of punctation."—Forbes, 1845.

Type Locality.—New Jersey.

Shell involute, perforate, globose, ovate to subcylindrical in outline, constricted basally; body whorl well rounded, medially inflated; external surface sculptured with close-set, faintly incised spirals; aperture more produced than the body whorl in front and behind, rather narrow and slightly arcuate posteriorly, broader and strongly patulous anteriorly; outer lip thin, sharp, straight medially, rounded at the extremities; parietal wall free from callous; columella feebly reinforced, non-plicate.

Haminea mortoni (Forbes) is separated from *Haminea cylindrica* by the much more inflated outline with the consequently greater constriction at the base of the body.

Occurrence.—MATAWAN FORMATION. Three-quarters of a mile below Ulmstead Point on the Magothy River, Anne Arundel County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum.

Outside Distribution.—*Monmouth Formation*. Navesink marl, New Jersey. *Selma Formation*. *Exogyra costata* zone, Wilcox County, Alabama; east-central Mississippi.

HAMINEA CYLINDRICA n. sp.

Plate XVIII, Figs. 8, 9

Description.—Shell cylindrical in outline, slender, usually more or less compressed; spire involute, body whorl slender, cylindrical; aperture very narrow posteriorly, outer lip strongly patulous, the inner smooth and gently arcuate; external surface sculptured with twenty-five to thirty low, broad, flattened, medially sulcated spirals separated by linear interspaces.

This species is closely related to *H. mortoni* (Forbes), but the shell is much more cylindrical in outline and the diameter, both of the entire shell and of the body whorl only, is much more uniform in the new species than in *H. mortoni*. The figured material is squeezed, thus giving the outline a medial pseudo-inflation.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

Family ACTEOCINIDAE

Genus ACTEOCINA Gray

[Proc. Zool. Soc., London, 1847, p. 160]

Type.—*Acteon wetherilli* Lea.

The name *Acteocina* was first used by Gray in 1847, as a possible subgenus of *Acteon*. He gave no description but he chose as his type of the new group of forms, "*Acteon wetherilli* Lea," which is not an *Acteon* but a representative of the genus *Tornatina* of A. Adams. Since Gray's publication has the priority, the rules of nomenclature have demanded that the familiar name of *Tornatina* be replaced by that of *Acteocina*.

Shell cylindrical or fusiform, thin, inflated; nucleus papillate and heterostrophous; spire slightly elevated; suture profoundly channelled; aperture narrow, linear; outer lip simple; columella calloused, bearing a single fold.

The recent species of this genus are for the most part characteristic of the deeper waters of the warm seas.

Etymology: Diminutive of *Acteon*.

ACTEOCINA FORBESIANA (Whitfield)

Tornatella Forbes, 1845, Quart. Jour. Geol. Soc., London, vol. i, p. 63, fig. c.
Actæon forbesiana Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 157, pl. xix, figs. 17-22.
Actæon cretacea Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 805. (Synonomy and figures excluded.)

Description.—" Shell of about a medium size for the genus, broadly ovate or ovoid in outline, spire short, obtusely rounded, middle portion of the shell subcylindrical and the base obtusely pointed, having nearly the same angle as that of the spire. Volutions from four to five in number, closely coiled and rising but slightly one above another; body volution very slightly chamfered just below the suture, presenting an almost imperceptible angle a little below the suture, below which it is nearly cylindrical to below the middle of its length, and obtusely pointed at the lower extremity. Aperture two-thirds the length of the shell, and considerably longer than the diameter of the body volution, very narrow at the upper part, but gradually widening below, rounded in front. Columella comparatively strong, bearing a single oblique ridge near the middle of its length, and having the margin thickened below it and around the base of the aperture, as seen by the impression of these features on the internal casts. Surface of the casts marked by rather fine, closely arranged, spiral lines, which may have been punctate on the shell, as on one of the casts there are indications of such a feature having existed; this, however, is by no means certain. No transverse markings, other than perhaps fine lines of growth, are indicated on any of the specimens present.

" The species differs from any of the associated forms in the proportions of the shell, being much more robust than in *Acteon gabbana,* and much less so than *A. bullata.* In fact it is of a very different type from the latter species. It bears some relation to *Acteon ovoidea* Gabb, but is a much shorter and smaller species, and has been entirely destitute of the broad longitudinal ribs credited to that one; nor has it had a second fold on the columella in advance of a ' large broadly rounded ' one as described on that shell, the fold being quite faint and slight on all the specimens examined. The figure given by Lyell and Forbes above cited is quite char-

acteristic, and shows a somewhat larger individual than any which I have seen."—Whitfield, 1892.

Type Locality.—New Jersey.

Weller included this species together with *Acteon ovoidea* Gabb under the name of *Acteon cretacea* Gabb. The type of *A. cretacea* is much crushed and shows no trace of spiral sculpture, although it quite possibly may have been present originally. It differs further, however, in the development of two strong columellar plications. *Acteon ovoidea* Gabb is less cylindrical and more ovoidal in outline with a much more rounded body whorl, more sharply constricted at the base.

Acteocina forbesiana (Whitfield) has a very meager representation in Maryland.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Columbia University, New Jersey Geological Survey.

Family SCAPHANDRIDAE

Genus CYLICHNA Lovén

[Ind. Moll. of Scandinavia, 1846, p. 10]

Type.—*Bulla cylindracea* Pennant.

Shell small, subcylindrical, involute; frequently umbilicated; spire deeply perforated at the summit; aperture narrow, the outer margin longer than the axis of the shell; labrum sharp; labium thickened anteriorly and bearing a more or less conspicuous plication.

A genus that has been in existence since the Mesozoic and is represented in nearly all of the recent seas.

CYLICHNA RECTA Gabb

Plate XVIII, Figs. 10, 11

Bulla recta **Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 302, pl. xlviii, fig. 16.**

Cylichna recta **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 16.**

Etymology: κυλίχνη, a small cup.

Cylichna recta Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 164, pl. xx, figs. 10, 11.
Cylichna recta Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.
Cylichna recta Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 814, pl. xcix, figs. 17, 18.

Description.—" Shell small, subcylindrical; spire very much depressed; mouth nearly straight and narrow. A cast."—Gabb, 1840.

Type Locality.—Green marl, Burlington County, New Jersey.

Shell small, involute, subcylindrical in outline; aperture more produced than the body whorl both posteriorly and anteriorly; external surface smooth medially, sculptured with faintly incised lines upon the anterior third and the posterior fourth, the posterior spirals numbering only about half a dozen and more distantly spaced than the twelve or fifteen anterior spirals; aperture narrow, expanding slightly in front and somewhat patulous; outer lip thin, sharp, approximately vertical, and parallel to the body wall; columella reinforced and slightly reversed at the base of the body; parietal wall entirely free from callous.

This small species is exceedingly rare in Maryland.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Wenonah sand, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey.

Order CTENOBRANCHIATA

Suborder TOXOGLOSSA

Family CANCELLARIIDAE

Genus PALADMETE n. gen.

Type.—*Trichotropis cancellaria* Conrad.

Shell rather small and thin, spire more or less scalariform, moderately elevated; the aperture in the type species approximately half as high as the entire shell; nucleus paucispiral, thrice coiled in the type species, the

Etymology: πάλαιος (paleo-), ancient; *Admete*, a genus of the Cancellariidae characterized by the absence of columellar folds.

initial turn and a half largely submerged in the succeeding volution; external sculpture reticulate, the axial costæ evanescing on the base of the body; aperture holostomous, outer lip thin, sharp, broadly arcuate; inner lip deeply excavated at the base of the body; columella non-plicate; anterior extremity of the aperture bent slightly forward and constricted to form an incipient canal; parietal wall washed with callous; umbilicus closed but indicated by a feeble depression behind the reverted labium.

This genus differs from *Trichotropis,* to which the type species has been commonly referred, in the nuclear characters, the general contour of the shell and the closed umbilicus. The protoconch is similar to that of *Cancellaria,* but the absence of any trace of columellar plications excludes the form from the typical section of the genus. It differs from *Admete* in the peculiar forward twist of the anterior portion of the aperture and the less clearly indicated anterior canal. *Admete* has not been reported from strata lower than the Pliocene, and though the genera are apparently closely related, it seems better to keep them distinct until further material makes their closer relationship more obvious.

PALADMETE CANCELLARIA (Conrad)

Plate XVIII, Figs. 14, 15

Trichotropis cancellaria Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iii, p. 333, pl. xxxv, fig. 8.

Description.—" Acutely subovate; volutions five; spire subscalariform; body whorl ventricose; longitudinal ribs narrow, prominent, distant; revolving lines prominent, distant, with an occasional minute intermediate line; columella profoundly incurved; labium reflected; base subumbilicated; shoulder of body volution with minute revolving lines, and one larger than the others."—Conrad, 1858.

Type Locality.—Owl Creek, Tippah County, Mississippi.

Shell small, nassoid in outline, spire a little higher than the aperture; whorls seven in number, the earlier turns increasing regularly in size, broadly convex, the later tabulated posteriorly; nuclear turns approximately three in number, the initial whorl and a half very small and largely immersed in the succeeding volution, the final nuclear turn relatively

elevated and broadly convex; external surface cancellated, axial sculpture of about fifteen narrow, rounded, sharply pinched costals separated by wider concave intercostals; axials tending to become irregular and to evanesce upon the final half turn and upon the base of the pillar; axials overridden by narrow, flattened, equisized and equispaced spiral fillets, uniform in character upon the costal and intercostal areas, separated by channeled interspaces, slightly wider than the spirals; primaries four in number upon the penultima and five or six on the ultima; two or three secondaries developed upon the shoulder and three or four at the base of the body; body whorl evenly rounded anteriorly; aperture holostomous, ovate to lenticular, outer lip thin, simple, broadly arcuate; inner lip excavated at the base; aperture constricted at its anterior extremity to form an incipient canal; parietal wall calloused; umbilicus closed by the reverted labium; area directly behind it feebly depressed.

Conrad's description implies a perforate shell, but there has been not even a chink of an umbilical opening in any of the numerous individuals examined from the Gulf as well as from Maryland.

Paladmete cancellaria is widely distributed through the Monmouth of the Gulf and the Middle Atlantic Coast.

Occurrence.—MONMOUTH FORMATION. One-half mile east of Millersville, Anne Arundel County; Brightseat, 1 mile west of Friendly, Prince George's County.

Collections.—Maryland Geological Survey, U. S. National Museum.

Outside Distribution.—*Ripley Formation. Exogyra costata* zone, Union and Tippah counties, Mississippi.

Family TURRITIDAE

Genus TURRIS Bolten

[Mus. Bolt., 1798, p. 123]

Turris anon., 1797, Mus. Calonnianum, pp. 34, 82; nude name, including *Turris babylonius*.

Pleurotoma Lamarck, 1799, Prodrome, p. 73; sole example *Murex babylonius* Linné.

Turris Dall, April, 1906, Jour. Conch. (Leeds), vol. xi, p. 291.

Turris Dall, 1909, Prof. Paper U. S. Geol. Survey, No. 59, p. 24.

Etymology: *Turris*, tower.

Type.—*Murex babylonius* Linné.

"The name *Turris,* proposed by Rumphius, and used in the same sense by Müller, Argenville, and other polynomial writers, was first used binomially in the anonymous Museum Calonnianum, where the names are all nude; but in a copy in my possession, under *Turris babylonia,* '*Murex babylonius* Lin.' is written in Humphrey's handwriting. Cossmann is mistaken in supposing that *Turris* in this work is used to indicate *Turritella* Lamarck; that genus is called *Terebra* by the anonymous author. In the following year the genus was again adopted for the same type of shell in the Museum Boltenianum. In this work, of twenty-two species cited under *Turris,* three are nude names; of the nineteen remaining, which are furnished with references, seventeen are *Pleurotoma,* twelve of which are referable to *Murex babylonius* (L.) Gmelin, one to *M. javanus* Gmelin, and four to *P. auriculifera* Lamarck. The other two references are to a pleurotomatiform Stromb, the *Strombus vittatus* Linné. The first species and type is *T. babylonius.*

"It is always regrettable to part with an old and familiar name, but in the present case, if the rules of nomenclature be followed, there is absolutely no escape from the conclusion above indicated. We can only regret that Lamarck disregarded a century of usage and tradition when he adopted the new name *Pleurotoma* in place of the familiar old one *Turris.*" —Dall, 1909.

Shell fusiform; body whorl of nearly equal length with the spire; columellar margin smooth; siphonal notch narrow and deep, placed some distance in front of the suture line; anterior canal long and straight.

The genus has been in existence since the Cretaceous and is present to-day in nearly all the warm seas.

A. Altitude of adult shell not exceeding 10 mm............*Turris terramaria*
B. Altitude of adult shell exceeding 10 mm.
    1. Macroscopic spiral sculpture not restricted to the base of the body and the pillar.
        a. Spirals very fine and regular in size and spacing, exceeding 15 in number upon the penultima............*Turris sedesclara*
        b. Spirals faint and irregular in size and spacing, not exceeding 15 in number upon the penultima..............*Turris welleri*
    2. Macroscopic spiral sculpture restricted to the base of the body and the pillar............................*Turris monmouthensis*

TURRIS TERRAMARIA n. sp.

Plate XIV, Fig. 6

Description.—Shell very small and fusiform in outline; maximum diameter in front of the median horizontal; whorls probably six or seven in number, although neither this nor the apical characters are determinate as the apex is broken away; whorls of spire flattened in front of the posterior suture, very feebly inflated medially, increasing regularly and rather slowly in size; body whorl evenly inflated medially, flattened posteriorly, smoothly constricted basally; external sculpture dominantly spiral; axial sculpture restricted to inconspicuous, protractive, peripheral costæ, nodose in character, approximately twelve to a whorl, and to very short retractive riblets in front of the posterior suture, approximately twenty-five to a whorl; spiral sculpture also more or less irregular, the spirals seven or eight in number upon the penultima, the second and third from the anterior suture more prominent than the rest, the five posterior spirals upon the body lower and narrower than those in front of them; medial and basal portions of the body and the pillar sculptured with approximately twenty flattened liræ nearly uniform in size and spacing, though evanescent upon the axial nodes and increasingly more crowded toward the base of the pillar; interspaces squarely channeled, and, for the most part, narrower than the spirals, faintly striated by the incrementals; suture lines impressed; aperture rather narrow, clavate; outer lip thin, sharp, symmetrically arcuate; inner lip smoothly concave, apparently non-plicate; pillar straight and rather long.

Dimensions (imperfect individual).—Altitude 9.1 mm., maximum diameter 4.5 mm.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

TURRIS WELLERI n. sp.

Plate XIV, Fig. 7

Description.—Shell moderately large for the genus, fusiform in outline; whorls numerous, probably about ten in all; apical angle from 15° to 20°; apex broken away and nuclear characters lost; external sculpture dominantly axial; costæ rounded, rather prominently elevated, and, on the spire, uniform in prominence from the fasciole to the anterior suture, though tending to grow broader, undulatory and irregular in size and spacing upon the body; spiral sculpture of feeble and somewhat irregularly spaced, impressed lines approximately nine in number upon the penultima, equally faint upon the costal and intercostal areas; base of body whorl and pillar sculptured with relatively strong, elevated spirals, probably twelve to fifteen in all, rather distantly spaced upon the base of the body, increasingly more crowded toward the anterior extremity of the pillar; siphonal fasciole sharply differentiated by a deeply impressed linear sulcus, undulated by the costæ of the preceding volution; suture line distinct, closely appressed; aperture imperfect in the type, pyriform, its altitude probably a little less than half that of the entire shell; siphonal notch as deduced from the growth lines, in front of the fasciole; outer lip broadly arcuate; a little more gradually constricted anteriorly than posteriorly; inner lip excavated at the base of the body, non-plicate; parietal wall washed with callous; pillar long and straight.

Dimensions (imperfect individual).—Altitude 40.2 mm., maximum diameter 17.5 mm.

Turris welleri has no very striking diagnostic characters, although no other species described from this area combines the prominent and, with the exception of the body whorl, regular axial sculpture with the irregular and very faint spiral sculpture.

This species is named for Prof. Stuart Weller, of the University of Chicago.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

TURRIS SEDESCLARA n. sp.

Plate XIV, Figs. 1, 2

Description.—Shell large for the genus, fusiform in outline; apex of spire broken away and nuclear characters lost; whorls probably eight to ten in number; external sculpture dominantly axial; costals well rounded, abruptly elevated, somewhat irregular in size and spacing and tending to evanesce toward the aperture; nine in number upon the penultima, uniform in prominence from their initiation at the fasciole to the anterior suture; spiral sculpture of very faint and fine lirations which do not override the costals, approximately twenty in number on the penultima in front of the fasciole and eight less feeble striæ upon the fasciole; fasciole about one-fourth the width of the whorl, differentiated by a shallow sulcus and by the absence of any axials other than irregular growth sculpture; spiral sculpture upon the body whorl becoming increasingly coarser and more distant anteriorly; body whorl well rounded, not sharply constricted at the base; outer lip imperfect, broadly arcuate; inner lip smoothly concave; pillar straight and probably quite long (imperfect in the type); siphonal notch apparently very shallow and placed in front of the fasciole.

Dimensions (imperfect individual).—Altitude 37 mm., maximum diameter 19.5 mm.

This species is characterized by its rather large size, coarse and not very regular axial sculpture, and very fine and crowded spiral threading.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

TURRIS MONMOUTHENSIS n. sp.

Plate XIV, Figs. 3, 4

Description.—Shell rather slender, fusiform in outline, the maximum diameter in front of the median horizontal; spire much elevated, its sides flattened and converging at an angle of approximately 25°; whorls probably seven or eight in all; apex broken away so that exact number is inde-

terminate and nuclear characters are lost; external sculpture rather subdued; axials eight or nine in number on the later volutions, rather broad, rounded, and moderately elevated upon the earlier turns, but becoming increasingly broader, lower, and more undulatory, and on the body whorl, manifested chiefly as a regularly crenulated shoulder carina; fasciole nodulated, the nodes unusually regular in size and spacing and approximately double the number of the costæ; spiral sculpture restricted to the base of the ultima and the pillar, with the exception of very faint and irregular striæ which, when intersected by the equally faint incrementals, give to the surface a very finely cancellated aspect; base of the body lirated with four quite prominent spirals separated by slightly wider interspirals; pillar sculpture becoming increasingly finer and more crowded toward its anterior extremity; fasciole rather narrow, closely appressed, margined posteriorly by the impressed suture and anteriorly by a well defined sulcus, smooth excepting for the nodules; body whorl flattened, quite abruptly constricted at the base; aperture narrow, spatulate; siphonal notch, as deduced from the growth lines placed directly in front of the fasciole; outer lip thin, sharp, arcuate; inner lip smoothly concave; pillar long and straight with subparallel margins.

Dimensions (imperfect individual).—Altitude 47 mm., maximum diameter 17 mm.

This species is well characterized by its flattened whorls, rather feeble axial sculpture and the absence of macroscopic spiral structure, excepting upon the base of the body and the pillar.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County,

Collection.—Maryland Geological Survey.

Genus SURCULA H. and A Adams

[Genera of Recent Mollusca, vol. 1, 1853, p. 88]

Type.—*Pleurotoma javana* Linné.

Surcula differs from *Turris* in the characters of the operculum, the closer proximity of the siphonal notch to the posterior suture, and the tendency, in many individuals, toward a recurved anterior canal.

Etymology: ***Surculus*, a sprout.**

The genus was initiated late in the Cretaceous, culminated in the early Tertiary and is represented in the recent seas by less than fifty tropical species, most of them denizens of the Indo-Pacific waters.

SURCULA AMICA n. sp.

Plate XIV, Figs. 8, 9

Description.—Shell fusiform in outline, rather slender; whorls of spire flattened, closely appressed, increasing gradually in size; body whorl rather abruptly constricted at the base; apical angle approximately 25°; apex broken away in all available material, so that neither the exact number of volutions nor the nuclear characters are determinable; both axial and spiral sculpture developed, the former dominant; axial costæ very narrow, rounded, abruptly and prominently elevated, uniform in strength from the fasciole to the anterior suture and, on the ultima, well down to the base, twelve or thirteen in number upon the later whorls; spiral sculpture of very low, broadly rounded liræ separated by linear interspaces, six or seven in number upon the later whorls of the spire, fifteen to eighteen upon the ultima and pillar; siphonal fasciole about one-fourth as wide as the whorl, closely appressed behind, and obtusely nodulated by the costæ of the preceding volution, margined anteriorly by a shallow, broadly undulated depression; suture lines distinct, impressed; aperture probably a little less than half as high as the entire shell; rather narrow, lenticular in outline; labrum broadly and symmetrically arcuate; labium smooth, quite deeply excavated at the base of the body; parietal wall evenly washed with callus; pillar probably straight and rather long.

Dimensions (imperfect individual).—Altitude 23.5 mm., maximum diameter 11 mm.

Type Locality.—Friendly, Prince George's County.

This species suggests *Drillia tippana* Conrad in general contour and in the character of the axial sculpture. There is nothing, however, in Conrad's type to suggest the presence of a well developed and rather prominent spiral sculpture analogous to that of *S. amica* n. sp.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, and Friendly, Prince George's County.

Collection.—Maryland Geological Survey.

Superfamily RACHIGLOSSA

Family OLIVIDAE

Genus OLIVELLA Swainson

[Zool., Ill., vol. ii, 1831, pl. lviii]

Type.—Olivella danea Mawe.

Small polished, cylindrical shells, produced into tapering spires; aperture narrow posteriorly, dilated forward; outer lip simple, sharp; inner lip calloused near the suture, obliquely plicate forward.

The *Olivellæ* are separated from the *Olivæ* by the smaller size of the former, the less oblique, more shallow basal notch, the higher spire and, in the recent shells, by the presence of an operculum.

OLIVELLA MONMOUTHENSIS n. sp.

Plate XIV, Fig. 10

Description.—Shell heavy, rather large for the genus; slender, fusiform in outline, the maximum diameter falling near the limit of the anterior third; apex of spire broken away and number of whorls and nuclear characters lost; external surface smooth, polished, suture lines glazed over; aperture narrow, lenticular, outer lip broadly and symmetrically arcuate; inner lip smoothly concave; anterior canal short and straight with subparallel margins; parietal wall glazed, its outer margin apparently not well defined, an obtuse fold visible, however, sweeping in a gentle curve from the medial portion of the parietal wall to the anterior extremity of the outer lip; anterior canal emarginate in front.

Dimensions (imperfect individual).—Altitude 15 mm., maximum diameter 7 mm.

This species is not confusable with any described form from the Upper Cretaceous.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Etymology: *Olivella*, little olive.

Family VOLUTIDAE[1]

Genus ROSTELLITES Conrad

[Proc. Acad. Nat. Sci., Phila., vol. vii, 1855, p. 268]

Type.—Rostellites texanus Conrad.

"Univalve, elongated, with an expanded labrum, and having numerous oblique plaits on the columella."—Conrad, 1855.

Dr. Dall, who has so ably monographed the *Volutidæ*, differentiated the genus as follows:[2]

"The genus *Rostellites* is characterized by a usually thick shell with a tendency to cancellated sculpture of distant narrow ridges, more or less nodose at the intersections; by an acute apex and trochoid, minute nucleus; by a tendency to a notch or sulcus in the outer lip near the suture; and by the presence of several well-differentiated plaits on the pillar. A few species are thin and the form is extremely variable. The surface is not glazed, the pillar is nearly straight, and the incremental lines are conspicuous."

The genus is world-wide in its distribution in the Cretaceous, but has not been reported from the earlier Mesozoic nor from the Tertiary.

A. External sculpture dominantly spiral; maximum diameter of shell approximately one-quarter of its altitude....... *Rostellites nasutus*

B. External sculpture dominantly spiral; maximum diameter of shell more than one-quarter of its altitude.
   1. Altitude of adult shell exceeding 60 mm.; entire surface finely threaded spirally........................ *Rostellites marylandicus*
   2. Altitude of adult shell not exceeding 60 mm.; external surface not finely threaded spirally........... ? *Rostellites jamesburgensis*

ROSTELLITES NASUTUS (Gabb) Meek

Volutilithes nasuta Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 300, pl. xlviii, fig. 9.

Fulguraria nasuta Gabb, 1862, Proc. Acad. Nat. Sci., Phila. for 1861, p. 364.

Rostellites nasuta Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 21.

Rostellites nasutus Conrad, 1868, Cook's Geol. of New Jersey, p. 730.

Etymology: *Rostellum*, diminutive of *rostrum*, beak; γτης, allied to.

[1] The representation of the *Volutidæ* in the Maryland Upper Cretaceous is curiously meager. The recent *Volutes* are among the characteristic deep-water forms and it is probable that the absence of the group as a major factor in the univalve fauna is indicative of unfavorable shallow-water conditions under which the Matawan and Monmouth were laid down.

[2] Dall, 1890, Trans. Wagner Free Inst. Sci., Phila., vol. iii, pt. i, p. 72.

Rostellites nasutus Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 294.
Rostellites nasutus Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 86, pl. xi, figs. 1, 2.
Rostellites nasutus Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 25.
Rostellites nasutus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 786, pl. xcvii, figs. 1, 2.

Description.—" Shell elongated, narrow; whorls about four; spire very elevated; mouth about two-thirds the length of the shell; three folds on the columella; surface markings unknown. From traces on the cast, apparently marked by crossed revolving striæ."—Gabb, 1860.

Type Locality.—Monmouth County, New Jersey.

" Shell of moderately large size, sometimes attaining a length of nearly or quite five inches. Form slender, with proportionally short, turreted spire, varying from two-thirds the length of the body volution in the casts to not more than one-third in the shell itself; number of volutions uncertain, the type specimen having had about four; body volution slender, most ventricose near the upper part, marked by numerous spiral ridges with broader interspaces which have possibly been marked by smaller ridges between the large ones; the upper lines nearly parallel to the suture, but below they become more and more oblique, so that the lower ones become nearly parallel with the columella; aperture comparatively broad and the lip thin; columella marked by three or four very oblique folds, situated near the middle of its length; the upper three at equal distances from each other and the lower one a little more distant from the next above."—Whitfield, 1892.

The evidence of the former presence of the species in Maryland and Delaware is fragmentary, but it is so well differentiated from the other volutes by the very slender outline, numerous columellar plications, and the cone-in-cone aspect of the cast of the spire, that determinations may be made with assurance even from fragments.

Occurrence.—MONMOUTH FORMATION. Two miles north of Delaware City, on John Higgins farm, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey.

ROSTELLITES MARYLANDICUS n. sp.

Plate XV, Fig. 1

Description.—Shell very thin, highly polished, of moderate size for the genus; fusiform-elliptical in outline; whorls closely appressed, probably quite numerous and increasing but slowly in size; apical portion of shell broken away so that exact outline and characters of early turns are lost; whorls of the spire flattened dorso-ventrally, constricted posteriorly, the ultima broadly rounded and merging smoothly into the wide pillar; external ornamentation quite elaborate; axial sculpture of rounded, quite strongly elevated costæ, eleven or twelve to the whorl, subequal in size and spacing, though tending to be somewhat irregular toward the aperture, persistent with uniform vigor from the fasciole to the anterior suture upon the whorls of the spire and well down to the base of the body; axial sculpture upon the fasciole restricted to numerous more or less arcuate costæ; incremental in character and having no relation in number or arrangement to the axials in front of them; spiral sculpture very fine and crowded, least faint in the concave intercostal areas, more or less obsolete upon the summits of the costals and directly in front of the fasciole; liræ rounded, approximately thirty in number upon the penultima and fifty on the ultima, separated, for the most part, by linear interspirals but more distant as well as more prominent and angular upon the base of the body and the pillar; fasciole not cut off by a sulcus, but differentiated merely by the close appression and the abrupt evanescence of the prominent axials; suture lines quite deeply impressed; aperture rather broad, lenticular in outline, the outer lip thin, sharp, broadly arcuate, sinuated posteriorly by a feeble siphonal notch; inner lip broadly and smoothly concave; columellar plications apparently three in number, oblique, borne near the initiation of the pillar, evanescent before reaching the mouth of the aperture.

Dimensions.—Altitude 58 mm., maximum diameter 27 mm.

This species is well characterized by its broad, well rounded axials, close spiral threading, and the three equisized and equispaced columellar folds almost midway in position between the two extremities of the aperture. The type is unique.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

? ROSTELLITES JAMESBURGENSIS (Weller)

Volutoderma jamesburgensis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 777, pl. xci, figs. 22, 23.

Description.—"Shell of medium size, the dimensions of the type specimen being: Height 30 mm., maximum diameter 17 mm. Volutions about four in number, the spire of moderate height, apical angle about 58°. Suture well defined; just below the suture is a rounded ridge marked by conspicuous oblique costæ about 1 mm. apart on the outer volution; just below this ridge is a narrow, concave band, outside of which, upon the shoulder of the volution, is a series of strong rounded nodes about 3 mm. apart from center to center on the outer volution, which continue longitudinally as strong, rounded ribs to the anterior extremity of the shell. Surface also marked by fine vertical lines of growth; revolving lines entirely absent. The internal cast is similar in general form, the suture is well defined, the volutions are flattened above, or even slightly concave, towards the aperture, sloping downward to the line of maximum diameter beneath the row of strong nodes on the exterior, below which the sides are nearly vertical to the suture below, or in the body volution becoming concave towards the anterior extremity. The vertical ribs are shown on the internal casts, but are much weaker than upon the exterior of the shell."—Weller, 1907.

Type Locality.—Jamesburg, New Jersey.

Weller makes no mention of any columellar plications, nor does he give any reason for referring the species to *Volutoderma.* The Maryland individuals which have been tentatively referred to *R. jamesburgensis* are all fragmentary and inconclusive, but the general outline and the character of the sculpture certainly suggest *Cythara* quite as strongly as they do the Volutes.

Occurrence.—MONMOUTH FORMATION. ? Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey.

Genus VOLUTOMORPHA Gabb

[Proc. Acad. Nat. Sci., Phila., 1876, p. 290]

Type.—*Volutilithes conradi* Gabb.

"Shell elongate, fusiform; whorls cancellated by longitudinal and revolving ribs. Columella with one very oblique fold, and sometimes one or more smaller secondary folds. In shape this genus is not unlike the two preceding genera, but it differs from them all in having essentially a single large oblique fold. When more than one occurs the secondary folds are smaller than the large primary."—Gabb, 1876.

Dall, in his elaborate discussion of the *Volutidæ*,[1] has characterized the genus as follows:

"*Volutomorpha* is sculptured very much like a worn *Rostellites*. It differs from *Rostellites* in being covered with a thin glaze all over, and in having one large plait near the edge of the pillar instead of several subequal plaits. There is sometimes an excavation behind the plait, the posterior edge of which might be mistaken for a second obscure plait. There is a notch or sulcus near or at the suture, very strongly marked at the resting stages of the animal. The nucleus is minute, polished, trochoid. The very young (not larval) shell has all the characters of *Piestochilus* Meek. The adult shell is thick, the pillar straight; in the mature shell the plait lags behind and is hardly perceptible from the aperture, while in *Rostellites* it is strong to the end in the species I have seen. These shells, like *Rostellites*, may reach a length of 5 or 6 in. . . . . *Volutomorpha* may be regarded as a link between *Rostellites, Liopeplum* and *Volutilithes*, combining some of the features of each."

Etymology: *Voluta*, a spiral shell; μορφή, form.

[1] Dall, 1890, Trans. Wagner Free Inst. Sci., Phila., vol. iii, pt. i, p. 73.

The known distribution of the genus is restricted to the Upper Cretaceous of the East Coast and Gulf Region of the United States.

A. Posterior fasciole not sharply differentiated; axial costæ rounded. *Volutomorpha conradi*

B. Posterior fasciole sharply differentiated; axial costæ ∧-shaped. *Volutomorpha perornata*

VOLUTOMORPHA CONRADI Gabb

Plate XV, Fig. 8

Volutilithes conradi **Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 300, pl. xlviii, fig. 10.**

Fulguraria conradi **Gabb, 1862, Proc. Acad. Nat. Sci., Phila. for 1861, p. 364.**

Rostellites conradi **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 21.**

Rostellites conradi **Conrad, 1868, Cook's Geol. of New Jersey, p. 730.**

Volutomorpha conradi **Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 293.**

Volutomorpha conradi **Tryon, 1883, Struct. and Syst. Conch., vol. ii, p. 166, pl. liv, fig. 27.**

Volutomorpha conradi **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 71, pl. vi, fig. 21; pl. vii, figs. 1-4, ? 5.**

Volutomorpha gabbi **Whitfield, 1892,** ***Ibidem*****, p. 73, pl. vii, fig. 6; pl. viii, figs. 1-4.**

Volutomorpha conradi **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 25.**

Volutomorpha gabbi **Johnson, 1905,** ***Ibidem*****.**

Volutomorpha conradi **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 780, pl. xcii, figs. 6, 7; pl. xciii, figs. 1-3; pl. xciv, figs. 1-6.**

Description.—" Shell fusiform, tapering; whorls about four; spire small and but slightly elevated; upper side of the whorls subangular; surface markings unknown. From marks on the cast it was apparently ornamented by longitudinal ridges, crossed by revolving lines; one fold on the columella."—Gabb, 1860.

Type Locality.—Crosswicks, New Jersey.

" Shell large, some specimens apparently attaining a length of 4½ in., with a diameter of the largest volution of rather more than 1¼ in.; spire short, or only moderately elevated, although the general form of the shell is somewhat slender, the body volution, as viewed on the apertural side, forms fully four-fifths of the entire length, even in the condition of internal casts; upper volutions compact, convex on the sides, and rather squarish or suddenly rounded to the suture on the top; body volution very large and

very gracefully swollen or convex in the upper part, and prolonged and attenuated below, forming a long, gracefully tapered anterior beak with the columella slightly twisted; top of the volution rather suddenly contracted to the suture; aperture large, very elongate-elliptical in outline and prolonged below, where it becomes narrowed as the outer lip approaches the axis; columella slightly twisted and marked by from one to three very oblique folds, the middle one of which is usually the strongest; surface of the casts usually smooth, with the exception of (in some cases only) a few distant vertical folds on the upper ones, and on the extreme upper part of the body volution; but where the external features are preserved, the whole shell is marked by strong, rounded, vertical folds, and but little less strongly marked, rounded, spiral ridges; the spiral ridges moderately distant on the upper part of the volution, but becoming less strongly marked and crowded and finally almost obsolete toward the base."—Whitfield, 1892.

Volutomorpha conradi, though unmistakably present in the Cretaceous of Maryland, is very rare, and has not been found excepting in the form of casts or very poorly preserved shells. Only a single true columellar fold has ever been noted in any of the individuals properly referable to this species, and it is exceedingly doubtful if Whitfield was correct in his observation that the columella is marked "by from one to three very oblique folds."

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Magothy Formation.* Cliffwood clay, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey.

VOLUTOMORPHA PERORNATA n. sp.

Plate XVII, Fig. 2

Description.—Shell small for the group, rather slender, fusiform in outline, the maximum diameter falling near the anterior third; spire moderately elevated, the whorls closely appressed, flattened, narrowly tabulated, increasing uniformly in size within an angle of approximately

35°; posterior fourth of the whorl sharply constricted and appressed, cut off from the portion in front of it by a shallow sulcus; body whorl broadly rounded, evenly contracted at the base and merging gradually into the long, gently recurved pillar; external sculpture reticulate; axials in the form of sharp, abruptly and very prominently elevated axial ridges, separated by narrowly flattened, or feebly concave intercostals approximately seventeen in number on the later whorls, uniform in character from the fasciole to the anterior suture, interrupted at the margin of the fasciole and a little less elevated upon it, persistent on the ultima to the base of the pillar; spiral sculpture probably uniform in character over the entire surface and overriding the axials; spirals cordate, obtusely angulated, equisized and equispaced, the interspirals concave, and a little narrower; spirals about seven in number upon the later whorls of the spire—three upon the fasciole and four in front of it—and probably about twenty on the body and pillar, excluding the secondaries which are introduced near the base of the body; suture lines deeply impressed; character of aperture and number of columellar plications not known.

Dimensions.—Altitude 43 mm., maximum diameter 15 mm.

The apparent similarity of this species to *Volutomorpha* conradi (Gabb) in the general contour and character of the ornamentation has led to its assignment to this genus, although the discovery of further material may prove the reference incorrect. *V. perornata* is described from a cast of the exterior surface which has served as the unique type. It differs from *V. conradi* in the smaller size, posteriorly constricted and tabulated whorls and sharper, more prominently elevated, axial sculpture.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Genus LIOPEPLUM Dall

[Trans. Wagner Free Inst. Sci., Phila., vol. iii, pt. i, 1890, p. 73]

Type.—*Liopeplum lioderma* Conrad.

"*Liopeplum* is of smaller size than the two preceding groups. It is characterized by a minute trochoid nucleus, ribbed early whorls and

Etymology: λεῖος, smooth; πέπλος, an upper garment.

smooth body-whorl in the adult, all covered with a most elegant and polished glaze; also by its habit of depositing a band of callus above the suture on the periphery of the preceding whorl. The pillar is stout and slightly curved, and the plaits are three or more, weak and rather variable, somewhat as in *Volutolithes*. The sinus at the suture is notable but not very wide. The plaits are preceded on the pillar by a thin mass of glaze which extends over the well-marked siphonal fasciole, somewhat as in some *Olivæ,* but with less defined boundaries. The plaits are not well visible at the aperture and are situated on the thickest part of this callus. These are very beautiful fossils, though poorly preserved in most cases, and the genus seems to me valid."—Dall, 1890.[1]

The genus is restricted in its known distribution to the Cretaceous.

A. Callus deposited in an obtuse ridge behind the suture. *Liopeplum leiodermum*

B. Callus not deposited in an obtuse ridge behind the suture.
   1. Shell compressed dorso-ventrally, the whorls of the spire cyndrical in outline............................*Liopeplum cretaceum*
   2. Shell not compressed dorso-ventrally, the whorls of the spire trapesoidal in outline..................*Liopeplum monmouthense*

LIOPEPLUM LEIODERMUM (Conrad) Dall

Volutilithes (Athleta) leioderma Conrad, 1860, Jour. Acad. Nat. Sci., 2 ser., vol. iv, p. 292, pl. xlvi, fig. 32.

Lioderma lioderma Conrad, 1865, Proc. Acad. Nat. Sci., Phila., p. 184.

Liopeplum lioderma Dall, 1890, Trans. Wagner Free Inst. Sci., Phila., vol. iii, pt. i, p. 73.

Liopeplum leioderma Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 25.

Description.—" Subfusiform, smooth, and polished; spire scalariform, angle callous; shoulder over the aperture with a projecting callus; aperture long, effuse; labrum slightly notched or sinuous at the superior extremity; columella four-plaited; plaits very oblique; superior one obsolete."—Conrad, 1860.

Type Locality.—Tippah County, Mississippi.

A slender, much battered individual was collected in the Maryland Cretaceous which suggests *L. leiodermum* in the development of an obtuse rib of callus directly behind the suture. It is smaller than the type of

[1] Dall, 1890, Trans. Wagner Free Inst. Sci., Phila., vol. iii, pt. i, p. 73.

the genus, however, and the sides of the body are flattened instead of broadly inflated.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Ripley Formation.* *Exogyra costata* zone, Union County, Mississippi.

LIOPEPLUM CRETACEUM (Conrad)

Plate XV, Fig. 5

Volutilithes cretacea **Conrad, 1858, Jour. Acad. Nat. Sci., Phila., vol. iii, p. 333, pl. xxxv, fig. 16.**

Description.—"Fusiform; spire elevated; volutions contracted beneath the suture, irregular longitudinal ribs on the upper volutions. Length of fragment, 2½ in."—Conrad, 1858.

Type Locality.—Owl Creek, Tippah County, Mississippi.

Shell thin, highly polished, broadly fusiform dorso-ventrally compressed; aperture little more than half as high as the entire shell; whorls closely appressed, probably about six in number, subtrapezoidal in outline, those of the spire increasing uniformly in size, the body whorl very feebly constricted upon merging into the pillar; external surface smooth, excepting the broad and somewhat irregular, incremental corrugations; growth sculpture very prominent upon the later portion of the ultima, the incrementals broadly arcuate and parallel to the margin of the expanded outer lip; feeble fortuitous spirals occasionally developed at the base of the pillar; suture lines very closely appressed, the zone of appression approximately one-third the altitude of the entire whorl; aperture broadly lenticular; outer lip arcuate, abruptly constricted anteriorly; inner lip smoothly concave at the base of the body; pillar straight, biplicate; anterior extremity squarely truncate.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Friendly and McNeys Corners, Prince George's County.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Ripley Formation. Exogyra costata* zone, Owl Creek, Tippah County, Mississippi.

LIOPEPLUM MONMOUTHENSE n. sp.

Plate XV, Figs. 6, 7

Description.—Shell thin, highly polished, slender, fusiform in outline, the maximum diameter falling a little in front of the medial horizontal; whorls probably seven or eight in number, converging at an angle of 20° to 25°, flattened dorso-ventrally, the later volutions closely appressed and constricted directly in front of the suture, the body whorl broadly arcuate, smoothly rounded at the base and merging gradually into the broad pillar; early whorls of the spire sculptured with short, broadly rounded, retractive riblets, approximately ten to the whorl and restricted to the posterior half; incremental sculpture strongly developed on the appressed portion of the later whorls but no true costæ; spiral sculpture absent altogether; aperture narrow, elliptical; outer lip thin, sharp, broadly arcuate; inner lip smoothly concave at the base of the body; columellar plications three in number, the two posterior folds very feeble and evanescing before reaching the aperture, the anterior fold quite strongly elevated, twisted and thickened at the margin of the aperture and running parallel to the columella for about 3 mm. before its final evanescence; pillar imperfect, but probably broad and not very long, with rather distant parallel margins.

Dimensions (imperfect individual).—Altitude 47 mm., maximum diameter 22 mm.

This species is more evenly rounded and more regularly fusiform in outline than any other member of the genus reported from Maryland.

Occurrence.—MONMOUTH FORMATION. One mile west of Friendly, Prince George's County.

Collection.—Maryland Geological Survey.

Family MITRIDAE

Genus VULPECULA Blainville

[Dict. Sci. Nat., tome xxxi, 1824, p. 106]

Type.—*Voluta vulpecula* Linné.

"Animal tout-à-fait inconnu, coquille allongée, fusiforme; l'overture étroite, prolongée en une sorte de canal, le bord columellaire plissé; le bord droit avec un pli anguleux vers le tiers postérieur de sa longueur."—Blainville, 1824.

Turricula, the name under which these slender, fusiform Mitridæ are most commonly cited, was proposed in 1753 by Klein, who was not a binomial writer. Shumacher applied it in 1817 to a pleurotomid, probably the *Surcula* of H. and A. Adams, and thus preoccupied the name for a group entirely distinct from that with which it is commonly associated. De Montfort recognized the so-called Minaret shells as a distinct genus in 1810, selected as his type *Voluta vulpecula* Linné, but gave to the group the name *Turris,* already preoccupied by Bolten. Blainville accepted the diagnosis and type of de Montfort but substituted for *Turris* the specific name of the type.

VULPECULA REILEYI (Whitfield)

Turricula reileyi Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 92, pl. xi, fig. 8.

Turricula reileyi Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 791, pl. xcvii, fig. 10.

Description.—"Shell slender, extremely elongated, turreted; spire very much elevated and slender; whorls numerous, slightly convex on the surface and very distinctly banded on their lower margin; body volution proportionally more convex than the others, being swollen near the middle of its length; attenuate and rostrate below, and nearly or quite one-half the length of the shell as seen from the outside of the aperture; sutures very distinct, bordered by a broad band which is very distinctly separated from the other part of the volution by an impressed line nearly or quite as deep and distinctly marked as the suture line itself; surface of the shell marked by numerous vertical folds, with slightly concave spaces between;

Etymology: *Vulpecula,* a little fox.

the folds are narrow and distinct, and very slightly bent backward in the middle of their length in their passage across the volution, but not interrupted perceptibly at the line separating the band from the body of the volution, and become obsolete on the rostrated part of the last one. Besides the vertical folds, the entire shell is marked by sharp, closely arranged spiral lines, which are finer and more numerous on the upper part, becoming more distant and stronger below, especially on the lower part of the last volution, where they seem to have alternated with finer intermediate striæ. This latter feature may be only apparent, however, as the condition of the specimens is not such as entirely to establish this feature as a character of the shell. The crossing of the vertical folds by the spiral striæ in the upper volutions produced a very decided and beautifully cancellated structure."—Whitfield, 1892.

Type Locality.—Freehold, New Jersey.

Vulpecula reileyi Whitfield is so poorly preserved both in the New Jersey and in the Maryland material that the diagnostic generic features of the aperture, the number and disposition of the columellar folds and the characters of the outer lip, cannot be determined. In the Maryland material the columellar plications are, apparently, three in number.

Occurrence.—MONMOUTH FORMATION. Brightseat, and Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Columbia University.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

Family VASIDAE Adams

Genus XANCUS Bolten

[Mus. Boltenianum, 1798, p. 134]

Type.—*Voluta pyrum* Gmelin.

Shell moderately heavy, pear-shaped or fusiform; protoconch papillate. Spire varying in relative altitude from more than one-half to less than one-third that of the entire shell. Whorls rather numerous, flattened or angulated at the periphery. External sculpture dominantly axial, fre-

Etymology: Modification of East Indian vernacular name.

quently nodose. Whorls closely appressed at the sutures. Anterior canal straight, or very loosely sigmoidal. Outer lip strongly arcuate, not reinforced nor lirate within; inner lip much thickened and reflected; three robust, horizontal plaits borne near the base of the body. Umbilical chink occasionally visible between the canal wall and the reflected labium.

Xancus is separated from the *Volutæ* and *Mitræ* on the one hand and from the *Fasciolariæ* on the other by the development of the three uniformly strong, approximately horizontal folds on the medial or slightly posterior portion of the columellar wall.

The affinities of the East Coast Cretaceous *Xanci,* so called, are rather dubious. If they are true *Xanci* they are the only representatives of the genus reported from pre-Cenozoic strata. The genus occurs, however, throughout the Tertiary, though never abundantly. The recent forms are confined to the Indian Ocean and the Brazilian Coast. The Indian species, notably the type, are used in many of the Brahminic religious ceremonies.

A. Altitude of adult shell exceeding 30 mm.............*Xancus alabamensis*
B. Altitude of adult shell not exceeding 30 mm...........*Xancus intermedia*

XANCUS ALABAMENSIS (Gabb)

Cancellaria alabamensis Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 301, pl. xlviii, fig. 26.

Turbinopsis alabamensis Gabb, 1862, Proc. Acad. Nat. Sci., Phila. for 1861, p. 321.

Turbinopsis ? alabamensis Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 19.

Turbinella ? verticalis Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 82, pl. iii, figs. 14, 15.

Pyropsis alabamensis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 24.

Turbinella alabamensis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 768, pl. xci, figs. 1-6.

Description.—" Shell wide; spire low; whorls four; mouth expanded; three or four folds on the columella."—Gabb, 1860.

Type Locality.—Prairie Bluff, Alabama.

" Shell turbinate or subglobose, with a moderately elevated spire, which has an apical angle of about 90°, and consists of about three and a half volutions, which increase rather rapidly in size with the increased growth

of the shell, especially the last one, which is also very ventricose in the upper part, but rapidly contracted below, and produced anteriorly in a more or less extended beak; aperture elliptical in form, pointed at the upper angle and prolonged below; columella strong, marked opposite the middle of the aperture by three slender, almost thread-like oblique plications; surface of the volutions, as shown by the casts, marked by strong, rounded, vertical plications or folds, which become obsolete a little below the swell of the volution and are also less distinct on the outer half of the last one; about eleven of the folds may be counted on the outer whorl."—Whitfield, 1892.

The axials number approximately eleven to each of the later volutions. The shoulders of the whorls are finely lineated spirally, while the medial and posterior portions are wound with low, broad fillets separated by squarely channelled and somewhat narrower interspirals, about six in number on the later whorls of the spire.

The species has a very meager representation in the Monmouth of Maryland.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Wenonah sand, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey. *Selma Formation. Exogyra costata* zone, Prairie Bluff, Alabama.

XANCUS INTERMEDIA (Weller)

Turbinella intermedia Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 767, pl. xc, figs. 18-22.

Description.—"Internal casts short fusiform to subglobular in form, with about three volutions, the dimensions of two nearly complete examples being: Height 18 mm. and 13 mm., greatest diameter 17 mm. and 11.8 mm. Apical angle about 75°, the spire about one-third the total height of the shell, the volutions increasing somewhat rapidly in size, subangular on the periphery and marked by rather strong vertical nodes, which become obsolete before reaching the suture above, and also a short

distance below the periphery, about twelve nodes occurring upon the outer volution; the last volution rather rapidly contracting below and produced into a short anterior beak; columellar cavity of moderate width, bearing the impressions of three rather faint revolving folds. Only the internal casts of this species have been observed. These resemble similar casts of *T. alabamensis*, but they are always shorter, with the volutions less regularly rounded over the periphery, and they do not attain so large a size. They differ from the casts of *T. parva* in being somewhat larger, in having a more elevated spire and in the more nearly vertical position of the nodes. The species is, in fact, somewhat intermediate in its characters between *T. alabamensis* and *T. parva*, and has been observed only from the Merchantville clay marl, while these other two species are both Navesink species."—Weller, 1907.

Type Locality.—Lenola, New Jersey.

The species is represented in Maryland by a single cast from the Matawan of the Canal.

Occurrence.—MATAWAN FORMATION. Camp Fox opposite Post 236, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation*. Merchantville clay marl, New Jersey.

Family FASCIOLARIIDAE

Genus FASCIOLARIA Lamarck

[Prodrome, 1799, p. 73]

Type.—*Murex tulipa* Linné.

Shell fusiform; spire elevated; apex acute; aperture oval-elongate, terminating in an open, more or less twisted canal; columella furnished with oblique, diminishing folds, the anterior, as in the *volutes*, being the most prominent.

A. Shell slender, maximum diameter not more than 10 mm. *? Fasciolaria juncea*
B. Maximum diameter more than 10 mm.................. *? Fasciolaria sp.*

Etymology: *Fasciola*, little band.

FASCIOLARIA ? JUNCEA n. sp.

Plate XIV, Fig. 12

Description.—Shell slender, fusiform, the maximum diameter falling decidedly in front of the median horizontal; whorls probably about six in number, closely appressed, flattened, regularly increasing in size, converging at an angle of not far from 10°; body whorl abruptly constricted at the base; external surface sculptured with sharply rounded, somewhat arcuate axial riblets numbering 12 or 13 to the whorl, persistent from suture to suture and evanescing on the ultima about half-way across the base; spiral sculpture of faint linear striations, twelve in number on the later whorls of the spire and double that number upon the body; pillar closely threaded with some twenty liræ; characters of aperture obscured by the matrix, probably narrow with a thin arcuate labrum and a strongly concave, non-plicate labium; anterior canal slender, straight and probably rather long.

Dimensions (imperfect individual).—Altitude 20 mm., maximum diameter 7.3 mm.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

FASCIOLARIA (?) sp.

Plate XIV, Fig. 11

Description.—The spire of a large univalve, fusoid in outline, was collected at Brightseat. The whorls probably numbered eight to ten and increased rather slowly in size. They are very closely appressed, the width of the fasciole being not far from a fifth of the width of the entire whorl. The most striking feature is the axial sculpture, the costæ being narrow, rounded upon their summits and very prominently elevated, numbering about twelve to the whorl and separated by slightly wider intercostal areas. They are uniform in strength from the fasciole to the anterior suture and are apparently overrun by a fine spiral liration, although the surface is so weathered that the details of the sculpture are largely obliterated. The

aperture is rather narrow and lenticular in outline behind the canal; the outer lip is thick, sharp and symmetrically arcuate, the inner evenly concave; the characters of the canal are not known.

Dimensions.—Altitude of spire 45 mm., maximum diameter of body 28.5 mm.

It is to be hoped that a specimen may be collected in the near future which may be worthy to serve as the type of this remarkable species.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Genus PIESTOCHILUS Meek

[Check List Inv. Fossils, N. A., Cret. and Jur., 1864, p. 22]

Type.—*Fusus scarboroughi* Meek and Hayden.

" Differs from the typical species of *Clavellithes* in having the aperture acutely angular behind, in consequence of the outer lip being closely appressed to the body whorl above, instead of forming a kind of posterior canal; and in having the inner lip thin instead of thickened above."—Meek, 1864.

Twelve years later, with the aid of further material, he redescribed and discussed the genus as follows:

" Shells of small size, with spire and canal produced; volutions flattened or moderately convex and finely spirally striated, sometimes with vertical folds; plait or plaits of columella not exposed in a direct view into the aperture, very oblique, and occupying a higher position than in either of the foregoing; outer lip smooth within. . . . . The type of the group *Piestochilus* was originally referred provisionally to the genus *Fusus,* when only imperfect specimens, merely showing its form and surface markings, were known. Subsequently, on examining others, I was led to the conclusion that it could not be a true *Fusus,* and thought, from its general appearance, that it was at least more probably related to *Clavellithes* of Swainson. In removing it doubtfully, however, to the latter genus, I was strongly impressed with the belief that it would at least form

Etymology: πιεστός, compressible; χεῖλος, lip.

the type of a distinct subgenus, for which I proposed the name *Piestochilus,* in allusion to the closely appressed character of its outer lip above, as compared with that of *Clavellithes.* At a still later date, in examining other specimens, one of which was accidentally split longitudinally, the discovery was quite unexpectedly made that it has one or two small, but distinct, revolving plaits ascending all the way up the columella; though these are not seen at the aperture, especially when the latter is even partly filled with foreign matter; while, if continued around, so as to be seen at the inner side of the columella, they would appear at a higher position than in the typical forms of *Fasciolaria.* This discovery led to the more critical examination of the other Upper Missouri Cretaceous shells most nearly agreeing in form and general appearance with the genus *Fusus,* when it was found that these, too, possess one or more plaits, one, the columella, not appearing at the aperture, but readily found by breaking open specimens. Consequently, it becomes evident that probably none of our known Upper Missouri Cretaceous fusiform shells can be properly retained in the genus *Fusus* or *Clavellithes,* but that nearly all of them naturally arrange themselves near, if not within, the genus *Fasciolaria,* thus confirming, as far as the evidence goes, an opinion expressed by the writer in 1864 in the Smithsonian Check List of North American Cretaceous Fossils, that probably none of the species there provisionally retained in the genus *Fusus* really belonged to that group.

"A few species from older rocks have been referred to the genus *Fasciolaria;* but we have good reasons for believing that this group, even as here defined, was not introduced previous to the deposition of the later members of the Cretaceous system. The number of species, especially of typical *Fasciolaria,* was not even then quite limited; but the species of the *Piestochilus* and *Cryptorhytis* were more numerous. Indeed, it is highly probable that a considerable portion of the Cretaceous shells that have been referred by various authors to the genus *Fusus,* as well as some of those referred to *Fasciolaria,* will be found to present the characters of one or the other of the latter groups. I am not sure that either of these two latter sections occur in the Tertiary rocks; but the typical section of *Fasciolaria* ranges through the Tertiary, and probably attains its maximum develop-

ment in our existing seas, where some of the species grow to great sizes."—Meek, 1876.[1]

Later collections and investigations have produced further evidence in favor of the general observations made by Meek some forty years ago. The genus is restricted in its distribution to the Cretaceous of North America.

PIESTOCHILUS BELLA (Gabb) Whitfield

Volutilithes bella Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 300, pl. xlviii, fig. 7.

Fulguraria bella Gabb, 1862, Proc. Acad. Nat. Sci., Phila. for 1861, p. 364.

Rostellites bella Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur.. p. 21.

Rostellites bellus Conrad, 1868, Cook's Geol. of New Jersey, p. 729.

Volutomorpha bella Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 293.

Volutomorpha (Piestochilus) bella Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 74, pl. vi, figs. 15-18.

Volutomorpha bella Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 25.

Piestochilus bella Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 782, pl. xcvi, figs. 1-4; pl. xcii, figs. 4, 5.

Description.—"Shell fusiform, slender; whorls, five; spire elevated; mouth about three-fifths the length of the shell; two folds on the columella; surface markings unknown. A cast."—Gabb, 1860.

Type Locality.—Chesapeake and Delaware Canal, Delaware.

"Shell as shown by the cast, elongate, fusiform, and slender, with moderately full volutions and distinct suture lines; spire short, the body volution as viewed from the front forming from three-fourths to four-fifths of the entire length, and the narrow, anteriorly prolonged aperture more than one-half of the length; volutions four or more in number, the last one most ventricose above the middle of its length and narrowed and prolonged below; columella showing two strong oblique folds at about the middle of the aperture; surface unknown."—Whitfield, 1892.

Only a fragment of a cast, apparently a litle less slender and more angular in outline than the type, has been very dubiously referred to this species.

Occurrence.—MONMOUTH FORMATION. ? Two miles west of Delaware City, on John Higgins farm, Delaware.

[1] Rept. U. S. Geol. Survey Terr., vol. ix, p. 356.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

Genus ODONTOFUSUS Whitfield

[Mon. U. S. Geol. Survey, vol. xviii, 1892, p. 65]

Type.—*Fasciolaria slacki* Gabb.

"Shell univalve, fusiform, resembling *Fusus* or *Fasciolaria* in general appearance; spire elevated, with vertically plicated whorls; anterior extremity prolonged into a straight canal of greater or less extent; columella marked near or above the middle by a single oblique fold; surface probably lirated, although no evidence of such a feature remains on the casts.

"I am compelled to propose a new generic name for a group of species possessing the above characters, although reluctant to do so on internal casts. The specimens closely resemble specimens of *Fusus* or *Fasciolaria* in their elongated fusiform character and prominent volutions, which have been strongly marked by vertical folds; but they differ from either in the characters of the columellar ridge or fold. From *Fusus* they differ in its presence and in the straight beak, and from the other in having only a single ridge, which is placed much higher on the columella. Mr. Gabb noticed the ridge on the columella in his original description of *F. slacki,* and in some later remarks[1] he suggests its relation to *Piestochilus* Meek. Mr. Meek's genus usually possesses more than one fold, but differs very materially in the characters of the spire and the more elongated anterior beak. In fact, *Piestochilus* more closely resembles *Mitra* than *Fasciolaria.* It is somewhat uncertain whether there have been spiral striæ on the shell, no evidence of such feature being present on any of the many casts examined."—Whitfield, 1892.

None of the species thus far referred to this genus range beyond the Cretaceous of North America.

Etymology: ὀδούς, tooth; *Fusus*, a closely related genus.

[1] Proc. Acad. Nat. Sci., Phila., 1876, p. 282.

ODONTOFUSUS MEDIANS Whitfield

Odontofusus medians **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 67, pl. v, figs. 18, 19, ? 20, ? 21.**

Odontofusus medians **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 761, pl. xc, figs. 1, 2, ? 3-6** ***(ex parte).***

Description.—" Shell as known from casts, slender, turreted, with ventricose volutions, which are most convex above the middle of the exposed part; body whorl rapidly contracted below and extended into a slender, straight canal; spire slender, longer than the shell below when viewed from the back; apical angle 35° to 40°; volutions five in number, with strongly marked suture lines; columella slender, marked by a single, sharply defined, oblique plication near or perhaps below the middle of its length; aperture obliquely pyriform, broadest above the middle and narrowed below, equal to or longer than one-half the length of the entire shell; volutions marked by a moderate number of vertical folds which extend from suture to suture on the whorls, and on the body volution can be traced nearly to the axis of the shell and are directed slightly forward in their passage from above downward. No evidence of spiral lines on the surface can be seen.

" This species is intermediate between the other two species herein described, in its apical angle, in the ventricosity of the volutions, and in the number of vertical folds crossing the volutions. The last volution does not increase any more rapidly than those above, in which feature it agrees with *O. rostellaroides,* but differs from *O. typicus,* and in the comparative strength of the columella it differs from either in being more slender. The species is very marked and distinct from either of them and is readily recognized. On one of the examples there apears to be a very faint indication of a second plication on the columella a short distance above the generic one, which may or may not be real. But if a natural feature, the space between them is entirely flat. Other specimens show no evidence whatever of this second plication. The vertical folds crossing the volutions are also much stronger on the one having the second ridge, and it may possibly indicate a distinct species."—Whitfield, 1892.

Type Locality.—Upper Freehold, New Jersey.

Whitfield's species was described from two casts which present differences in the degree of convexity of the whorl and in the strength and persistence of the axial ribs which are probably specific. It is impossible to determine with assurance whether or not the shell figured by Weller from the Ripley of Mississippi is specifically identical with the New Jersey cast which served as Whitfield's type.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey.

Outside Distribution.—Matawan Formation. Marshalltown clay marl, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey.

Family FULGURIDAE

Genus PYROPSIS Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, 1860, p. 288]

Type.—Tudicla (Pyropsis) perlata Conrad.

" Spire very short, apex not papilated, labrum without striæ within, thick; columella without a fold."—Conrad, 1861.

Conrad later raised the group originally assigned to subgeneric rank under *Tudicla* to the rank of a genus, because, as he said, it differed from *Tudicla* " in having a subtruncated apex, not papillated, and a smooth inner surface of the labrum, no fold on the columella, and the mouth more expanded and angulated."—Conrad, 1869.[1]

The body whorl of *Pyropsis* is conspicuously inflated, frequently angulated at the periphery and very abruptly contracted at the base into a very slender and usually straight anterior canal, which is broken away in all but the most perfectly preserved specimens. The external sculpture is dominantly spiral, although the axials are frequently strong enough to render their intersections with the spiral liræ nodular or even subspinose, especially at the angle of the periphery. The aperture conforms to the outline of the body and exclusive of the canal is subcircular or broadly ovate in outline. The opening of the canal is very narrow, and its mar-

Etymology: *Pyrum*, a pear; ὄψις, form.

[1] Am. Jour. Conch., vol. iv, p. 248.

gins parallel. The inner lip is thin, sharp, widely reflected and discrete from the canal wall, at least in the anterior portion. The umbilical chink is narrow, but usually distinct.

Pyropsis has been definitely recognized only from the Cretaceous of the Atlantic and Gulf states and the western interior of North America, although some of the South India Upper Cretaceous species referred by Stoliczka to *Rapa* are certainly much more closely affiliated with *Pyropsis*. The affinities of certain so-called *Pyropses* from the Eocene are more doubtful.

A. Spire flattened; body whorl angulated at the shoulder... *Pyropsis perlata*
B. Spire often low but not flattened; body whorl not angulated at the shoulder.
  1. Primary spirals exceeding nine in number upon the body whorl.
    a. Spirals more or less undulated but not nodose, the primaries flattened and subequal in size and spacing. *Pyropsis trochiformis*
    b. Spiral sculpture on body whorl of alternating series of nodes and simple liræ.................... *Pyropsis reileyi*
  2. Primary spirals not exceeding nine in number upon the body whorl.
    a. Axial sculpture not developed............ *Pyropsis septemlirata*
    b. Axial sculpture developed.
      i. Axials uniform in size and spacing and approximately equal in width to the spirals.
        a′. Whorls flattened in front of the suture. *Pyropsis whitfieldi*
        b′. Whorls not flattened in front of the suture. *Pyropsis retifer*
      ii. Axials irregular in size and spacing, restricted, for the most part, to the ultima........ *Pyropsis lenolensis*

PYROPSIS PERLATA Conrad

Tudicla (Pyropsis) perlata Conrad, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 288, pl. xlvi, fig. 39.

Pyropsis perlata Tryon, 1883, Struct. and Syst. Conch., vol. ii, p. 142, pl. ii, fig. 61.

Pyropsis perlata Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 23.

Pyropsis richardsoni Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 739, pl. lxxxvi, figs. 2-5 *(ex parte)*.

Description.—" Pyriform, tricarinated; body whorl very wide, profoundly carinated and spinous above; the lower carina or rib less prominent than the middle one; revolving lines crenulated or subtuberculated, alternated on the upper part of the body whorl; aperture wide; labrum margin crenulated."—Conrad, 1860.

Type Locality.—Tippah County, Mississippi.

Pyropsis perlata Conrad is best characterized by a spire depressed almost to flatness, an angulated and abruptly constricted body whorl, an external surface ornamented with rugose, unequal spirals. The synonymy of the species is in a well-nigh hopeless state. Of the three names most intimately concerned, the first, *Pyropsis richardsoni* (Tuomey), is founded on an unfigured type which has been lost and which was originally described in less than two lines; the second, *Pyropsis perlata* Conrad, was founded on a shell, perfectly preserved excepting for the very tip of the spire and the anterior extremity of the canal; the third, *Pyropsis elevata,* was founded on an inside cast which has retained none of the original ornamentation. This has been omitted from the above synonomy because of an apparently less depressed spire and a less abruptly constricted body whorl. It is quite probable that *P. richardsoni* and *P. perlata* are specifically identical, but it is impossible to prove it, and for that reason it does not seem wise to perpetuate a name which can never be adequately defined unless the lost type should come to light.

The Matawan casts referred to this species are much smaller than the shells preserved in the Monmouth.

Occurrence.—MATAWAN FORMATION. Camp U & I, opposite Post 192, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Bohemia Bridge, Cecil County; Brightseat, and Brooks estate near Seat Pleasant, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Ripley Formation. Exogyra costata* zone, Tippah County, Mississippi.

PYROPSIS TROCHIFORMIS (Tuomey) Gabb

Plate XVI, Figs. 1, 2

Pyrula trochiformis Tuomey, 1854, Proc. Acad. Nat. Sci., Phila., vol. vii, p. 169.

Tudicla trochiformis Meek, 1864, Check List Inv. Fossils, N. A., Cret and Jur., p. 22.

? *Pyropsis trochiformis* Gabb, 1876, Proc. Acad. Nat. Sci., Phila., pp. 284, 285.

? *Pyropsis richardsonii* ? Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 39, pl. i, figs. 14-16. (Not *P. richardsoni* Tuomey, 1855.)
Pyropsis trochiformis ? Whitfield, 1892, *Ibidem*, p. 41, pl. i, figs. 4-7.
Pyropsis trochiformis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 23.
Pyropsis trochiformis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 746, pl. lxxxvii, figs. ? 1-10, 11 *(ex parte)*.

Description.—" Shell top-shaped; body whorl large, inflated, covered with revolving raised lines; spire depressed, not flat; angle of the body whorl rounded; canal produced; aperture nearly circular."—Tuomey. 1854.

Type Locality.—Noxubee County, Mississippi.

Shell large, an individual from Brightseat attaining a total altitude of probably more than 100 mm. and a maximum diameter of 75 mm.; spire low, but not flattened; whorls five or six in number, those of the spire obtusely carinated, the body whorl quite smoothly rounded in front of the shoulder, but rather abruptly constricted at the base; external surface, if the shell and the cast have not been incorrectly united, highly polished and sculptured with low, broad, spiral bands separated by angular interspirals of almost equal width, eleven to twelve in number on the ultima exclusive of the canal, and of fortuitous secondaries; the spirals subequal, the two shoulder spirals a little less prominent than those in front of them; characters of the canal not certainly known, but it was probably long and rather broad; aperture very wide, the outer lip thin, sharp, and semi-elliptical in outline, obscurely angulated at the shoulder; inner lip moderately excavated at the base of the body, non-plicate.

Pyropsis trochiformis, as used by Weller and others who were working with poorly preserved material, is little more than a group name which serves to include all of the larger casts of *Pyropsis* with rounded but not globose body whorls. The degree of variation in the convexity and in the sharpness of the contraction of the body is quite certainly much greater than would be allowed if the shell characters were preserved, but in the absence of these there are no very satisfactory criteria for separation.

P. trochiformis (Tuomey) is distinguished from *P. perlata* Conrad not only by its less depressed spire and rounded body whorl, but also by the development of a much simpler and more uniform and regular spiral sculpture than that which ornaments Conrad's species.

Occurrence.—MATAWAN FORMATION. ? Arnold Point, Severn River, Anne Arundel County. MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Marshalltown clay marl, New Jersey. *Monmouth Formation.* Navesink marl, Tinton beds. New Jersey.

PYROPSIS REILEYI Whitfield

Pyropsis reileyi Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 42, pl. ii, fig. 17.

Pyropsis trochiformis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 746, pl. lxxxvii, figs. 1-3 *(ex parte)*.

Description.—" Shell of medium size, subglobular or globularly ovate in general form, with a moderately elevated spire and subventricose volutions, which are somewhat rapidly enlarged outwardly; volutions about three in number, the last one forming the principal bulk of the shell, and regularly rounded from the suture line to the beginning of the very slightly extended anterior beak; the inner volutions nearly on a level with each other, but the outer one dropping more rapidly below the inner, giving the greater height to the spire; volutions regularly rounded, without any angulation in the upper part, especially on the last one; aperture large, semi-lunate, modified above on the inside by the projection of the inner volution; cavity left in the cast by the removal of the columellar axis very large and marked on the surface by a series of circular protuberances which gradually increase in size with the growth of the shell; the inner one of four, which can be seen on one cast, and which is situated at the inner limit of the last volution, is only about one-twelfth of an inch in diameter, while the outer one is rather more than one-fourth of an inch across; the surface of the shell marked by several strong, coarse, revolving ridges, which have left their imprint only very slightly on the surface of the cast; the outer lip of the shell seems also to have been slightly expanded, at least near the upper part of the aperture.

"This shell, as shown by the internal casts, differs from the other species herein described in its more elevated spire and rounded but less gibbous and less ventricose volutions, especially the outer one. The axis has also been much stronger in proportion to the size of the specimen, and the anterior canal shorter and less distinct. The peculiar flattened node-like protuberances on the columellar lip may be the result of accident. Indeed, it would seem almost impossible for the animal to have purposely formed and retained such protuberances, as they are not continuous or connected, but are each one isolated from the others, but their gradual increase in size as the shell has developed is a curious feature and gives them a meaning which they otherwise would not possess. The shell, however, is specifically distinct from the others, entirely independent of this peculiarity."—Whitfield, 1892.

Type Locality.—Holmdel, New Jersey.

Weller has united under *Pyropsis trochiformis* (Tuomey) all of the individuals described by Whitfield under the name of *P. reileyi.* Most of Whitfield's specimens are casts, but on one of them a surface sculpture has been preserved which is certainly distinct from that which has been associated probably correctly with *P. trochiformis.* The latter is wound with spiral bands, approximately uniform in size and spacing and more or less undulated by the axials but not nodose. In Whitfield's species the body whorl is sculptured with sharply nodulated spirals alternated with simple liræ. The general contour, however, differs very little from some of the manifestations of *P. trochiformis* (Tuomey) *sensu lato.*

Occurrence.—MONMOUTH FORMATION. ? Burklow's Creek, Cecil County.

Collections.—Maryland Geological Survey, Columbia University.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

PYROPSIS SEPTEMLIRATA Gabb

Cancellaria septemlirata **Gabb, 1861, Proc. Acad. Nat. Sci., Phila. for 1860, p. 94, pl. ii, fig. 10.**

Cancellaria ? septemlirata **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 19.**

Cancellaria ? septemlirata **Conrad, 1868, Cook's Geol. of New Jersey, p. 729.**
Pyropsis septemlirata **Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 285.**
Pyropsis (Rapa?) septemlirata **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 44, pl. iii, figs. 4-6.**
Pyropsis septemlirata **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 24.**
Pyropsis septemlirata **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, pl. lxxxviii, figs. 1-4** ***(ex parte).***

Description.—" Shell subglobose, spire low, whorls two, mouth wide, surface, from markings on the cast, apparently ornamented by about seven prominent revolving lines. A cast."—Gabb, 1861.

Type Locality.—Mullica Hill, New Jersey.

" Shell, as shown by the internal casts, depressed globular or broadly oblate in general outline, the volutions being very ventricose, and the spire low, the inner volutions rising but very little above the outer ones, and the base in the casts being quite short; volutions probably not more than three and a half or four in number, and very rapidly expanding, so that the last one forms nearly the entire bulk of the shell, the outer one being slightly angular in the upper part; aperture large, semi-lunate or semi-elliptical, as wide as or wider than high, modified on the inner upper half of the preceding volution, and slightly extended below by the projection of the short columella upon which there appears to have been a strong, angular ridge; surface marked by very strong, angular, spiral ridges with concave interspaces; seven or eight of these may be counted below the angulation of the outer volution, including the angle itself, and two or three smaller ones above this point on large specimens; those below the angulation gradually decrease in distance and become more and more oblique as they approach the columella."—Whitfield, 1892.

Whitfield is incorrect in his observation of a columellar fold. The inner lip is non-plicate. The species is represented in Maryland by a single worn cast referred rather dubiously to this form.

Occurrence.—MONMOUTH FORMATION.—Bohemia Mills, Cecil County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

PYROPSIS WHITFIELDI Weller

Pyropsis octolirata **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 36, pl. ii, figs. 8, 9. (Not *P. octolirata* Conrad, 1858.)**

Pyropsis whitfieldi **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 750, pl. lxxxviii, figs. 14-16.**

Description.—" Shell small, subglobular or subpyriform in form, with about three ventricose, rapidly expanding volutions; the dimensions of a nearly complete internal cast being: Height 19.5 mm., which might be increased to 25 mm. if the anterior canal were complete; maximum diameter 16 mm.; height of spire 5.5 mm. Spire low-conical, volutions distinctly flattened adjacent to the suture, marked by from six to nine spiral ridges or costæ upon the casts, which are crossed by vertical ridges at about equal intervals or slightly more distant than the spiral lines, the two sets of markings dividing the surfaces into a number of square, depressed spaces; anterior beak short, apparently straight, and rather pointed; aperture elongate, pointed above and below, about half as wide as long. In the casts the suture is distinct and often strongly marked.

" *Remarks.*—This species is of about the same size as *P. retifer,* from which it may be distinguished by the distinctly flattened band on the upper side of the volutions adjacent to the suture; the spire is also slightly more depressed, and the lower side of the outer volution contracts a little more rapidly to the anterior beak. The species has only been seen in the condition of internal casts, and by Whitfield was referred to *P. octolirata.* It differs from *P. octolirata,* however, in the presence of vertical ribs, and apparently also in the flattening of the upper margin of the volutions." —Weller, 1907.

Type Locality.—Crosswicks Creek, New Jersey.

The representation of this small *Pyropsis* in Maryland is very fragmentary.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, and Friendly, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

PYROPSIS RETIFER (Gabb) Whitfield

Plate XV, Figs. 9, 10

Fusus retifer Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 301, pl. xlviii, fig. 11.

Fusus ? retifer Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 22.

Perissolax retifer Conrad, 1868, Cook's Geol. of New Jersey, p. 730.

Pyropsis retifer Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 38, pl. ii, figs. 1-4.

Dolium (Doliopsis?) multiliratum Whitfield, 1892, *Ibidem*, vol. xviii, p. 121, pl. xv, figs. 4-6.

Pyropsis retifer Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 24.

Pyropsis retifer Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 749, pl. lxxxviii, figs. 7-13.

Description.—" Shell pyriform; spire slightly elevated; mouth wide, outer lip slightly reflected (?); surface crossed by two series of impressed lines so as to present a pavement-like appearance."—Gabb, 1860.

Type Locality.—Mullica Hill, New Jersey.

" Shell small, pyriform, or without the anterior canal subglobular in form, the dimensions of a large individual being: Height 22 mm., or probably 25 mm., if the anterior beak were complete; maximum diameter 18 mm.; height of spire 6 mm. Volutions about three, rounded, ventricose and rapidly increasing in size, rapidly contracting below to the short anterior beak, spire low, conical, sutures well marked in the cast; aperture large, subcircular on the outer margins, about two-thirds as high as the total height of the shell; columellar cavity in the cast rather narrow. Surface of the casts marked by eight or ten spiral ridges upon the body volution, placed at nearly equal intervals, also by fainter vertical ridges which appear usually to have been placed at nearly equal intervals to those of the spiral ridges, though occasionally they are somewhat closer. Upon the external surface, as shown in impressions of the outside, the revolving and vertical ribs are much more conspicuous than on the casts, their intersections being marked by small, rounded nodes."—Weller, 1907.

External surface sculptured with broad flattened spirals, three in number on the penultima and nine in number on the ultimate whorl, separated by the flattened or feebly concave interspiral areas, double the width of the

spirals; cordate secondaries introduced midway between the primaries on the body whorl and upon the shoulder; axial sculpture less regular in character and spacing than the spiral, axials rather more closely spaced than the primary spirals, excepting toward the aperture where they are more distant; entire surface finely and regularly striated by the incrementals.

Well preserved casts are cancellated by the axials and primary spirals, but show no trace of any secondary spiral sculpture. The species is represented in Maryland by a single crushed cast to which fragments of the shell substance still adhere.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—Matawan Formation. Wenonah sand, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey.

PYROPSIS LENOLENSIS Weller

Plate XVI, Fig. 3

Pyropsis lenolensis **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 752, pl. lxxxviii, figs. 20-24.**

Description.—" Shell small, and, exclusive of the anterior beak, subglobular in form, with about four volutions; the dimensions of a nearly complete individual are: Height 13 mm., probable height, if anterior beak were complete, 18 mm., maximum diameter 11.5 mm., height of spire 4 mm. The volutions distinctly flattened above in a spiral band just below the suture, the outer margin of the flattened band being elevated in a moderately strong revolving rib, below this rib the outer volution is nearly regularly convex to the base of the anterior canal, which is rather elongate and slender; surface of the outer volution marked by about six or seven strong, revolving ribs between the outer margin of the flattened band above and the base of the anterior beak, the outer half of the volution being also marked by several rather strong, vertical varices which are

about twice as far apart as the revolving ribs, these varices do not cross the flattened band above, and at their junction with the revolving ribs they are elevated into rounded nodes; entire surface of the shell also marked by somewhat irregular, transverse lines of growth. On the internal casts the transverse varices are well marked, but the revolving ribs are faint except at the junction with the varices; the columellar cavity narrow.

"This species most closely resembles *P. whitfieldi,* but, besides being confined to an entirely different geologic horizon, the flattened upper margin is more distinct, the vertical markings are mere remote varices in the outer half of the last volution of the adult shells rather than regular ribs covering the entire shell with a distance apart about equalling the spaces between the revolving ribs. Furthermore, the vertical varices in *P. lenolensis* end at the outer margin of the upper flattened spiral band, while in *P. whitfieldi* the ribs apparently continue to the suture, judging from the internal casts alone."—Weller, 1907.

Type Locality.—Lenola, New Jersey.

Occurrence.—MATAWAN FORMATION. Chesapeake and Delaware Canal (exact locality unknown).

Collections.—Maryland Geological Survey, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey.

Genus SERRIFUSUS Meek

[U. S. Geol. Survey, Territories, vol. ix, 1876, p. 373]

Type.—*Fusus dakotensis* Meek and Hayden.

"Shell short-fusiform; body volution large, and bicarinate or tricarinate, with carinæ more or less nodose; spire and canal moderate, the latter bent and more or less twisted; outer lip broadly but slightly sinuous in outline, between the upper carina and the suture. . . . . The type for which the subgeneric name *Serrifusus* is here proposed seems to be entirely destitute of any traces of such plaits on the columella, and in other respects more nearly related to the genus *Fusus,* though its shorter, bent

Etymology: *Serra,* saw; *Fusus,* a gastropod genus.

canal, larger body volution, and the somewhat sinuous outline of the upper part of its outer lip, seem to require its separation, at least subgenerically."—Meek, 1876.

Serrifusus is one of the many ancestral types of *Fusus* which seem to offer differences sufficient to warrant their isolation until a monographic study is made of the entire group and the phylogenetic relationships established once for all.

SERRIFUSUS NODOCARINATUS Whitfield

Serrifusus (Lirofusus) nodocarinatus Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 64, pl. v, figs. 22, 23.

Serrifusus nodocarinatus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 760, pl. lxxxix, fig. 13.

Description.—" Shell of medium size, abruptly fusiform in general outline; spire broad conical, the height from the broadest part of the body volution being somewhat less than the diameter at its periphery; beak short, slender; volutions three or four (the specimen being imperfect), somewhat bicarinate in the middle where there is a nearly vertical, obliquely flattened area or band, above which the surface slopes rapidly to the suture and is very slightly concave; below this point the volution contracts very abruptly to the short, slender canal, leaving the body volution somewhat compressed-discoidal or wheel-like in form, which in the specimen is possibly exaggerated by vertical crushing; periphery of the volutions marked by rather strong, transverse node-like vertical folds, which are also continued in less strength above and below, and the entire surface is occupied by spiral ridges of considerable strength, but which alternate in size on the lower part of the volution; four or five of these revolving ridges occupy the upper side; about three mark the vertical space of the periphery, and seven or more may be counted on the lower side of the body volution, in the poorly preserved specimen used; aperture not seen." —Whitfield, 1892.

This species is represented in Maryland by a single cast to which fragments of the shell substance still adhere.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Columbia University.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

Genus PYRIFUSUS Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iii, 1858, p. 332]

Type.—*Pyrifusus subdensatus* Conrad.

" Pyriform, columella broad, thick, flattened; body volution transversely oval."—Conrad, 1858.

In 1876 Meek united under *Pyrifusus* the typical species of Conrad and a group of forms differing from *P. subdensatus* in the higher, more evenly inflated spire, the sinuous outer lip and the flattened columella. The latter he assigned to the subgenus *Neptunella,* a name unfortunately preoccupied by Gray in 1853.

It seems probable, however, that the differences are of more than subgeneric significance, but *Pyrifusus* sensu stricto is not represented in the Maryland faunas, and so it seems wiser to leave the status of the group unchanged until further material is available. *Rhombopsis,* a name suggested by the conspicuously rhomboidal outline of the shell, may be substituted for the preoccupied *Neptunella.* The composite genus is described by Meek as follows:

" Shell varying from subpyriform to short-fusiform; spire one to three-fifths the length of the aperture and canal, not papillate at the apex; body volution rather ventricose and prominent, or obtusely subangular around the upper third, dorso-ventrally compressed, or more generally rounded, tapering below into a nearly straight, moderately produced canal; aperture rhombic-subovate in outline, being angular, but not notched or canaliculate above, and tapering downward; outer lip thin, sometimes broadly sinuous above the middle; columella solid, gently arcuate along the middle, nearly straight, and without twist below, sometimes more or less flattened, but always without the slightest umbilical ridge, and at least

Etymology: A name which combines the roots as well as the characters of *Pyrula* and *Fusus*.

typically imperforate; inner lip smooth, and closely attached to the columella and body volution; surface with vertical, sometimes node-like folds around the most convex part of the volutions, and revolving striæ, or small ridges.

"The foregoing diagnosis is drawn up so as to include, along with Mr. Conrad's typical form, a group of apparently congeneric Upper Missouri Cretaceous species, that still seem to differ in some of their characters."—Meek, 1876.[1]

The genus is not known to occur except in the Upper Cretaceous.

A. Height of aperture equal to or more than half the altitude of the entire shell.
  1. Axials less than eleven to the whorl, increasingly prominent toward the aperture.............*Pyrifusus marylandicus*
  2. Axials more than 11 and less than 15 to the whorl.
    a. Base of body whorl more or less excavated.
      i. External sculpture vigorous, spiral sculpture on body whorl not restricted to the base.......*Pyrifusus vittatus*
      ii. External sculpture subdued, spiral sculpture on body whorl restricted to the base....*Pyrifusus monmouthensis*
    b. Base of body whorl obliquely truncated........*Pyrifusus cuneus*
  3. Axials more than 15 in number.................*Pyrifusus whitfieldi*
B. Height of aperture less than half the altitude of the entire shell. *Pyrifusus elevata (?)*

PYRIFUSUS MARYLANDICUS n. sp.

Plate XVI, Figs. 7-9

Description.—Shell rather short, fusiform, thin, fragile; maximum diameter falling a little in front of the median horizontal; whorls probably six or seven in all, closely appressed, broadly convex; body whorl inflated, smoothly constricted at the base; axial sculpture manifested in the shape of low, broad undulatory costæ, approximately nine or ten to the whorl, not very prominent even upon the periphery and evanescing entirely in front of and behind it, but becoming increasingly prominent toward the aperture and, on the final half turn, appearing as narrow but very prominent ridges, rounded upon their summits, and separated by profound troughs, the ridges abruptly evanescent in front of the appressed posterior band and before reaching the base of the ultima; spiral sculpture uniform in general character over the entire external surface, the liræ

[1] Rept. U. S. Geol. Survey, Territories, vol. ix, p. 343.

approximately twenty-five in number upon the ultima, finest and most crowded upon the appressed band, evanescent upon the summits of the costæ and somewhat wider and less regular upon the base of the body; interspiral area linear or sublinear over the entire surface from the apex to the anterior extremity; aperture narrow, obliquely lenticular; outer lip symmetrically arcuate; inner lip smoothly concave; anterior canal short, broad, ill-defined.

Dimensions (slightly imperfect specimen).—Altitude 22.5 mm., maximum diameter 14.4 mm.

Type Locality.—Brightseat, Prince George's County.

This species is well characterized by the very prominent axial ridges which strongly undulate the periphery of the ultima, and by the very fine, spiral threading which covers the external surface.

Occurrence.—MONMOUTH FORMATION. Brightseat, Friendly, McNeys Corners, 1 mile west of Friendly, Prince George's County.

Collection.—Maryland Geological Survey.

PYRIFUSUS VITTATUS n. sp.

Plate XV, Fig. 4

Description.—Shell rather thick, crumbly, of moderate size for the genus; slightly compressed dorso-ventrally, ovate in outline; aperture about four-fifths as high as the entire shell; spire depressed, the whorls rapidly enlarging, very closely appressed, submerged beyond the periphery, approximately five or six in number; body whorl broadly but not very strongly inflated, slightly constricted basally; shoulder of the whorl the only portion visible on the spire, forming a feebly convex area between the sutures, the outline obscured, however, by the heavy sculpture; axials approximately thirteen in number, nodulating the periphery of the whorl, rapidly evanescing behind the periphery on the body, persisting as irregular, undulatory costæ well down to the base of the whorl; turns of the spire so closely appressed that the posterior portion is more or less nodulated by the costæ of the preceding volution, leaving only the narrow medial position of the shoulder free from axial sculpture; spirals not developed

behind the periphery but very prominent upon the body; body spirals rather low, broad, flattened fillets which override the costals in undiminished vigor, separated upon the posterior portion of the whorls by interspirals of approximately equal width but becoming more rounded, more elevated, and less distant anteriorly; sutures impressed but rather indistinct; aperture rather wide, arcuate; outer lip broadly rounded, apparently subvaricose; inner lip oblique, non-plicate; pillar flattened; canal short, broad, recurved.

Dimensions (slightly imperfect individual).—Altitude 32.5 mm., maximum diameter 25 mm.

This species suggests in general contour *P. subdensatus* Conrad. It is at once separable, however, by the nodose axial sculpture upon the spire and the coarser spiral sculpture.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

PYRIFUSUS MONMOUTHENSIS n. sp.

Plate XVI, Figs. 5, 6

Description.—Shell compressed dorso-ventrally, broadly lenticular in outline, the maximum diameter falling near the median horizontal; spire scalariform, multispiral, the exact number of whorls not known but probably about six; whorls very sharply constricted at the fasciole, the posterrior portion closely appressed against the preceding volution, the anterior portion nearly horizontal; sides of the whorls not far from vertical, the ultima flattened and obliquely tapering at the base; axial sculpture of narrow, pinched costæ, subequal in size and spacing upon the spire, evanescent at the fasciole and upon the base and the final half turn of the ultima; appressed portion of whorl finely nodulated but not in close harmony with the axials; spiral sculpture restricted to the sides of the whorls on the spire, and a few faint liræ at the base of the body, those of the spire approximately seven in number, least feeble near the fasciole, those on the body perhaps ten in all; suture lines distinct, impressed, minutely crenu-

lated; aperture rather narrow, obliquely lenticular; labrum thin, sharp, broadly arcuate; labium smoothly and symmetrically concave, non-plicate; pillar flattened; anterior canal short, broad, ill-defined.

Dimensions (imperfect individual).—Altitude 34.9 mm., maximum diameter 22.6 mm.

This species is characterized by the subdued external sculpture, the evanescence of the axials upon the final half turn, and the absence of spirals upon the anterior and medial portions of the ultima.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

PYRIFUSUS CUNEUS Whitfield

Pyrifusus cuneus **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 51, pl. iv, fig. 9-11.**

Pyrifusus cuneus **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 24.**

Pyrifusus mullicaensis **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 733, pl. lxxxv, figs. 12, 13** ***(ex parte).***

Description.—" Shell of medium size, short-fusiform, nearly twice as long below as above the periphery of the last volution when viewed from in front, and almost regularly sloping from that point to the pointed anterior extremity, as seen in the cast; apical angle about 50° or 55°; volutions about four; subangular on the periphery and marked by moderately distant but distinct vertical folds, which are obsolete on the lower third of the volution, but increase in strength and distance with the increased growth of the shell. Twelve of these folds can be counted on the body whorl of the best preserved cast. Umbilical cavity in the cast, as left by the removal of the columella, large and destitute of markings or folds of any kind; aperture cuneate-elliptical, sharply pointed below and angular above; surface characters of the shell unknown.

" This species is of about the size of *P. erraticus,* but differs somewhat in the form of the volutions and in the less elevation of the spire. The volutions are more angular on the periphery and the angulation is comparatively higher than in that species, while the vertical folds are more closely arranged. The lower portion of the volution is also not constricted

between the body of the volution and the anterior beak, so that the shell is of a wedge-shaped form below the periphery. It somewhat closely resembles *P. newberryi* Meek and Hayden."—Whitfield, 1892.

Type Locality.—Freehold, New Jersey.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Monmouth Formation.* New Jersey.

PYRIFUSUS WHITFIELDI n. sp.

Plate XIV, Fig. 5

Description.—Shell rather thick, of average size for the genus; broadly elliptical in outline, the maximum diameter falling near the median horizontal; whorls probably five or six in number, very closely subscalariform in outline, the shoulder of the whorl occurring in front of the closely appressed band and not at the extreme posterior margin of the volution; body whorl ovate in outline, obliquely constricted basally; external sculpture ornate, axials narrow, rounded riblets, nineteen to twenty-one in number upon the later turns, separated by concave intercostals, persistent from suture to suture upon the spire, though partially dissected at the fasciole, evanescent on the body whorl at the fasciole before reaching the base; spiral sculpture uniform in general character over the entire surface; spirals broad, flattened fillets overriding the costals separated by slightly narrower interspiral areas $\pm$ 6 in number on the later whorls of the spire and 16 on the body whorl, including the two less prominent liræ upon the fasciole; aperture imperfect, lenticular in outline, the outer lip broken in the type; inner margin smoothly concave; the pillar flattened and non-plicate; anterior canal short, broad, ill-differentiated, its anterior extremity broken in the type.

Dimensions (imperfect specimen).—Altitude 29 mm., maximum diameter 23 mm.

This species is best characterized by the numerous undulatory axials and the fillets which are wound about it from the apex to the base of the pillar.

This species is named in memory of Robert Parr Whitfield.

The species is rare in a good state of preservation, but determinable fragments are not uncommon in the Monmouth of Brightseat.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

? PYRIFUSUS ELEVATA Whitfield

Turbinopsis elevata **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 102, pl. xii, figs. 13, 14.**

Turbinopsis elevata **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 26.**

Turbinopsis ? elevata **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 797, pl. lxxxiii, figs. 14, 15.**

Description.—" Shell of moderately small size as indicated by internal casts only; spire elevated, consisting of but few whorls, which in the casts are widely disconnected, indicating a thick shell or whorls disconnected in the shell itself, which is most probable; volutions rounded above and on the periphery, but compressed and wedge-form below; aperture elongate-ovate, rounded above, but wedge-shaped below; umbilical opening, in the cast, quite large, smooth, not showing any indication of the spiral tooth-like ridge; surface of the cast showing rather distant vertical folds, but very little indication of spiral striæ, the shell being probably too thick for them to be transmitted to the cast."—Whitfield, 1892.

Type Locality.—Crosswicks, New Jersey.

As Weller implied in his discussion of the generic affinities of this cast, it is much easier to state the genus to which the form does not belong than to name that to which it does. The entire absence of columellar plications excludes the species from *Modulus.* The large umbilical funnel and the apparently heavy shell suggest *Pyrifusus,* although the spire is relatively high and the body whorl low and narrow for that genus.

Occurrence.—MONMOUTH FORMATION. One mile west of Friendly, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—Monmouth Formation. Navesink marl, New Jersey.

? PYRIFUSUS (immature)

Plate XVI, Fig. 4

Description.—Shell very small, fusiform, whorls probably about six in number, those of the spire feebly convex, the body whorl quite strongly so; maximum diameter not far from the median horizontal; axial sculpture of sharply rounded riblets, broader and more obtuse upon the body, eighteen in number on the later whorls; spirals cordate in character, four in number on the penultima, with possibly a secondary upon the obscure shoulder; somewhat nodulated at the intersections with the axials, the interareas between the spirals and axials forming a series of squarish pits; spirals upon the body less regular in character than upon the spire; primaries ten upon the body, excluding the pillar, more distantly spaced upon the periphery, rather lower and more obtuse than upon the spire and with regularly intercalated secondaries; pillar threaded with nine to twelve subequal liræ which become increasingly more crowded toward the anterior extremity; characters of aperture not known.

Type Locality.—Two miles southwest of Oxon Hill, on Mrs. Linton's farm.

Occurrence.—MONMOUTH FORMATION. Two miles southwest of Oxon Hill, Prince George's County.

Collection.—Maryland Geological Survey.

Family BUCCINIDAE

Subfamily CHRYSODOMINAE

Genus EXILIA Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, 1860, p. 291]

Type.—*Exilia pergracilis* Conrad.

Shell fusoid in outline, much attenuated, multispiral, external sculpture delicate, the costals numerous and slightly arcuate, the spiral threading fine and crowded; aperture narrow, produced anteriorly into a long straight canal; outer lip sharp and simple; columella non-plicate.

The genus has formerly been considered in its American distribution to be restricted to the Eocene.

Etymology: A corruption of *exilis*, slender.

EXILIA CRETACEA n. sp.

Plate XIV, Fig. 13

Description.—Shell very small and slender; whorls probably not less than ten in a perfect individual, very broadly convex, increasing very slowly in size; body whorl rather abruptly constricted at the base into a very slender canal; external surface axially and spirally sculptured, the axial sculpture dominant, particularly upon the later whorls; axials rather irregular, feebly arcuate upon the whorls of the spire, sinuous upon the body, persistent from suture to suture upon the whorls of the spire, abruptly evanescent on the body before reaching the base, fifteen or sixteen in number on the whorls of the spire, nine or ten on the body; entire surface overridden from apex to pillar with very fine and crowded concentric striæ, eight on the whorls of the spire, double that number on the body exclusive of the base and the pillar; characters of aperture not known.

Dimensions.—Altitude 10 mm., maximum diameter 3.7 mm.

The affinities of this small species are rather doubtful, but the outline and characters of the sculpture seem to justify its reference to *Exilia*. *Exilia* has been reported from the Maestricht beds, but never before from the Cretaceous of this continent.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Family PURPURIDAE

Genus MOREA Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, 1860, p. 290]

Type.—*Morea cancellaria* Conrad.

"Short-elliptical; aperture much longer than spire; columella reflexed. concave, with a prominent, acute fold at base."—Conrad, 1860.

Shell heavy, ovate in outline. Whorls not very numerous, flattened, scalariform. External sculpture vigorous, dominantly spiral, aperture broadly lenticular, a little more than half as high as the entire shell, outer lip heavy, inner lip reinforced, narrowly reflected, bearing a single rather

feeble fold not far from the anterior extremity; aperture emarginate in front. Umbilicus narrow, oblique, the last of the body spirals constituting an obtuse umbilical keel. The genus has been shifted back and forth between the *Purpuridæ* and the *Cancellariidæ,* but Conrad was probably correct in referring it to the former. It differs from *Purpura* chiefly in the rather wide umbilicus and in the strength of the columellar plait. The differences between *Morea* and *Cancellaria* are much more significant. The contour both of the shell and of the aperture differ from that of *Trigonostoma,* the subgenus that includes all the umbilicate *Cancellariæ.* The general character of the sculpture is purpuroid rather than cancellate. Those *Cancellariæ* in which the number of columellar folds is reduced below the normal retain those upon the medial portion of the whorls longest. In *Morea* it is the anterior plait which persists while no trace of medial plications can be detected.

The genus is restricted in its known distribution to the Upper Cretaceous of the East Coast and Gulf.

A. Maximum diameter approximately two-thirds of the altitude; axial sculpture more or less irregular and incremental in character. *Morea naticella*

B. Maximum diameter less than two-thirds the total altitude; axial sculpture of well-defined fillets, uniform in size and arrangement. *Morea marylandica*

MOREA NATICELLA Gabb

Plate XVIII, Fig. 12

Purpura (Morea) naticella Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 301, pl. xlviii, fig. 14.

Morea naticella Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 19.

Morea naticella Conrad, 1868, Cook's Geol of New Jersey, p. 729.

Pyropsis naticoides Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 43, pl. ii, figs. 5-7.

Morea naticella Whitfield, 1892, *Ibidem*, p. 97, pl. xii, figs. 19, 20.

Pyropsis naticoides Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 24.

Morea naticella Johnson, 1905, *Ibidem*, p. 26.

Morea naticella Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 800, pl. xcviii, figs. 14, 15.

Description.—" Shell patulous; whorls four; mouth wide; surface marked by longitudinal ribs, crossed by lighter revolving lines. A cast.

This species resembles *M. cancellaria* Con., but can be distinguished by its more elevated spire and its more robust form."—Gabb, 1860.

Type Locality.—New Jersey.

"Shell of medium size, subglobular or subpyriform, with three or four ventricose volutions, which are most inflated on the upper third. The dimensions of a nearly complete internal cast are: Height 19 mm., maximum diameter 16 mm., height of aperture 17 mm., width of aperture 8 mm. Spire rather low; aperture broadly elliptical, pointed above and obtusely so at the base; columellar cavity of medium size, with a single strong spiral ridge near the anterior margin. Surface of the shell marked by eight to eleven strong spiral ridges, leaving a plain space at the base of the shell equal in width to that of two of the ridges; surface marked also by somewhat more distant, transverse, broadly rounded ridges, which are nodose at the points of junction with the revolving ridges."—Weller, 1907.

The form tentatively referred to this species presents a relatively stronger spiral sculpture than the type. The specimen in question is a well preserved cast of the external surface. The spire is reticulately ornamented and its surface marked off into a series of squarish pits approximately uniform in size and arrangement. On the body the wide, flattened spirals dominate the narrower and much less prominent axials which, though they partially dissect the spiral fillets, are little more than vigorous incrementals.

Occurrence.—MATAWAN FORMATION. Chesapeake and Delaware Canal (exact locality not known).

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Matawan Formation.* Merchantville clay, New Jersey.

MOREA MARYLANDICA n. sp.

Plate XVIII, Fig. 13

Description.—Shell rather small for the genus, ovate-elliptical in outline; aperture probably about two-thirds of the total altitude; spire very imperfect, but probably composed of only a few flattened whorls minutely

tabulated posteriorly; body whorl slightly oblique, and very feebly constricted at the base; external sculpture ornate, reticulate, the spirals dominant; axials about twenty-five in number, low, obtusely angulated, uniform in size and spacing, separated by intercostals of approximately equal width; spirals low, flattened fillets, twelve in number on the body of the type, for the most part, equisized and equispaced, overriding the costals and somewhat nodulated at the intersections; areas included between the costals and spirals forming a series of squarish pits; space between the two posterior spirals upon the ultima wider than the rest and quite strongly concave, cut up by the costæ into numerous rectangular pits; aperture rather narrow; outer lip broadly arcuate; parietal wash very heavy; siphonal fasciole distinct; anterior extremity emarginate; other apertural characters concealed by the solid matrix.

Dimensions (imperfect specimen).—Altitude 19 mm., maximum diameter 12 mm.

Type Locality.—Two miles southwest of Oxon Hill on Mrs. Linton's branch, Prince George's County.

This species runs smaller and relatively more elongate than its southern analogue, *M. cancellaria* Conrad. In general aspect it is much less rude and heavy than Conrad's species, and the external sculpture, though similar in character, is much finer and more delicate.

Occurrence.—MONMOUTH FORMATION. Brightseat and 2 miles southwest of Oxon Hill, Prince George's County.

Collection.—Maryland Geological Survey.

Family STROMBIDAE

Genus PUGNELLUS Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, 1860, p. 284]

Type.—*Strombus densatus* Conrad.

" General form of *Strombus,* with a labrum angular and salient at the upper extremity, with sinus in the upper margin contiguous to the angle or protuberant end of the tip, the outer margin of labrum and submargin very thick or callous; beak straight or curved forwards. This genus

Etymology: Diminutive of *pugnus*, fist.

embraces four known species, all of which characterize the Cretaceous period. One occurs in South America, and two in India. The latter are *Strombus uncatus* Forbes, and *S. contortus* Sowerby."—Conrad, 1860.

Shell stout, fusiform in young stages, very heavy and irregularly ovate or trigonal in the adult. Spire rather low, whorls feebly inflated, as a rule, and increasing rather rapidly in size, the earlier volutions partially concealed in the adult forms by the labial flange. External sculpture dominantly axial, body whorl relatively large, aperture wide posteriorly, narrowly contracted anteriorly, thickened marginally, smooth within, produced either into a trigonal flange or into a subfalcate process. Columellar lip very heavily calloused, the wash covering a greater or less surface of the body whorl and spire. Columella feebly excavated, non-plicate, anterior canal short and narrow, sharply recurved into a dextral beak abruptly truncated in front and rarely preserved in its entirety.

The genus is represented by something more than a dozen species, all of them from the Cretaceous.

A. Axial sculpture developed upon final half turn.......*Pugnellus densatus*
B. Axial sculpture not developed upon final half turn....*Pugnellus goldmani*

PUGNELLUS DENSATUS Conrad

Strombus densatus Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iii, p. 330, pl. xxxv, fig. 14.

Pugnellus densatus Conrad, 1860, *Ibidem*, 2d ser., vol. iv, p. 284.

Pugnellus densatus Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 20.

Pugnellus densatus Hill, 1901, 21st Ann. Rept. U. S. Geol. Survey, pt. vii, pl. xlviii, fig. 2.

Pugnellus densatus Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 23.

Pugnellus densatus Veatch, 1906, Prof. Paper U. S. Geol. Survey No. 46, pl. x, fig. 3.

Pugnellus densatus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 720, pl. lxxxiii, fig. 6.

Description.—"Lip expanded, very thick; costæ disappearing on the middle of the volution; labrum suddenly thickened, with a groove behind the raised margin; a calcareous deposit sometimes coats the whole shell, rising into an oblique, thick, prominent ridge, the upper margin of which is on a line with the apex."—Conrad, 1858.

Type Locality.—Owl Creek, Tippah County, Mississippi.

Represented in Maryland by a single imperfect form to which only enough of the shell adheres to show the diagnostic axial sculpture upon the final half turn, a character which in the absence of the flange of the outer lip serves to separate it from *P. goldmani.*

Occurrence.—MONMOUTH FORMATION. Railroad cut 1 mile west of Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survery, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Wenonah sand, New Jersey. *Black Creek Formation.* ? North and ? South Carolina. *Ripley Formation. Exogyra costata* zone, Eufaula, Alabama; Union and Tippah counties, Mississippi.

PUGNELLUS GOLDMANI n. sp.

Plate XVII, Figs. 5, 6

Description.—Shell large for the genus and relatively thin, quite highly polished; outline exclusive of the alate outer lip, broadly and symmetrically lenticular, the maximum diameter falling near the median horizontal; whorls five in number, very closely appressed, regularly and rather rapidly increasing in size, those of the spire trapezoidal in outline, not constricted at the sutures so that the sides of the spire converge evenly and uninterrupted to the obtuse apex at an angle of approximately 35°; body whorl smoothly and gently rounded; external surface smooth, excepting for two or three incipient axial undulations upon the periphery of the final half turn, and for the faint incremental striations; sutures very closely appressed and indistinct; outline of aperture rudely and somewhat obliquely rectangular; outer lip alate, produced backward upon the penultima, thickened marginally, acutely angulated posteriorly at approximately 90°; labium oblique to feebly convex, roughly parallel to the lateral margin of the labrum; parietal wall free from wash; anterior extremity imperfect.

Dimensions (imperfect individual).—Altitude, 54 mm.; maximum diameter, exclusive of outer lip, 25 mm.; maximum diameter, including outer lip, 42 mm.

The species is remarkable among the *Pugnelli* for the symmetry of the outline, the relatively thin shell, and the absence of sculpture. The type is, unfortunately, unique.

This unusually well preserved and interesting form is named in honor of Dr. Marcus I. Goldman, a former student of the Johns Hopkins University.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Family APORRHAIDAE

Genus ANCHURA Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, 1860, p. 284]

Type.—*Anchura abrupta* Conrad.

Shell, exclusive of expanded outer lip, slender, fusiform in outline, multispiral; whorls of spire flattened or feebly convex, tapering uniformly to an acute apex; body whorl disproportionally large, and frequently more inflated than those of the spire. External sculpture dominantly axial; vigorous spirals sometimes developed on the body. Suture line distinct, impressed, outer lip much expanded and produced either into a single falcate process or two digitate processes, the one anterior and the other posterior; inner lip thickened but not plicate. Anterior canal very long and very slender, often a little sinuous.

The expanded outer lip and slender anterior canal are broken away in the majority of the fossils. Most of the Maryland representatives are in the form of casts, recognizable by the posteriorly directed outer lip.

Anchura is characteristically a Cretaceous genus and quite certainly did not persist into the Tertiary. It may, however, have been initiated in the Jurassic, although the affinities of those Jurassic species referred to it are rather dubious.

Etymology: ἄγχι, near; οὐρά tail. A name suggested by the resemblance of the anterior canal to a tail.

A. Shell small or of average dimensions; whorls neither conspicuously convex nor conspicuously flattened; external surface sculptured with 10 to 20 axial costæ.

1. Shell rarely exceeding 25 mm. in altitude; axials usually exceeding 15 in number on the later whorls............*Anchura rostrata*

2. Shell usually exceeding 25 mm. in altitude; axials rarely exceeding 15 in number on the later volutions..........*Anchura pennata*

B. Shell large; whorls conspicuously convex; external sculpture not known ....*Anchura hebe*

C. Shell small, very slender; whorls conspicuously flattened; external surface sculptured with numerous sigmoidal axial costæ. *Anchura pergracilis*

ANCHURA ROSTRATA (Gabb) Meek

***Rostellaria rostrata* Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 390, pl. lxviii, fig. 7.**

***Anchura (Drepanochilus) rostrata* Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 19.**

***Anchura rostrata* Conrad, 1868, Cook's Geol. of New Jersey, p. 729.**

***Rostellaria rostrata* Conrad, 1875, Kerr's Geol. Rept. of North Carolina, App., p. 12. (Not *Anchura rostrata* Conrad, Kerr's Geol. N. C., App. p. 12, pl. ii, fig. 28.)**

***Alaria rostrata* Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 119, pl. xiv, figs. 5, 6.**

***Alaria rostrata* Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 23.**

***Anchura rostrata* Weller, 1907, Rept. Geol. Survey of New Jersey, vol. iv, p. 709, pl. lxxxi, figs. 7-9.**

Description.—" Fusiform, outer lip very much produced laterally; whorls six; canal moderately long; surface marked by nodes on the angle of the whorl, which are prolonged below into ribs extending over a large portion of the whorl; other markings (?). Casts."—Gabb, 1860.

Type Locality.—Burlington County, New Jersey.

Shell exclusive of the expanded outer lip slender, fusiform; whorls eight to ten in number, those of the spire flattened or feebly convex, increasing regularly in size; body whorl inflated, quite abruptly constricted and acutely pointed anteriorly; external surface sculptured with fifteen to twenty feebly arcuate axial costæ which persist from suture to suture on the earlier whorls but tend to evanesce posteriorly on later volutions, subequal in size excepting for an occasional subvaricose costal, and approximately uniform in spacing; suture lines closely appressed, minutely undulated by the costæ of the preceding volution; aperture rather wide, subquadrate; outer lip widely alate, produced backward

beyond the penultima; anterior and posterior margins of the wing convex, the anterior more strongly so than the posterior; outer margin subvertical or feebly oblique.

The shell of *A. rostrata* (Gabb) is best characterized by the subquadrate wing and the numerous, rather narrow, obtuse and feebly arcuate axial riblets. It is not only smaller than the closely related *A. pennata* (Morton), but it differs further in the more rapidly enlarging whorls.

Anchura rostrata is the most conspicuous gastropod in the Matawan along the Chesapeake and Delaware Canal. The material is in a very poor state of preservation, the forms occurring as casts, most commonly in the iron nodules. The casts are small for the genus, not more than 20 mm. high, as a rule, and are characterized by the angular outline and the numerous axial plications.

Occurrence.—MATAWAN FORMATION. Post 105, Summit Bridge, ? one-eighth of a mile west of Summit Bridge, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Woodbury clay, Wenonah sand, New Jersey. *Ripley Formation. Exogyra costata* zone, Tippah County, Mississippi.

ANCHURA PENNATA (Morton) Conrad

Rostellaria pennata Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 48, pl. xix, fig. 9 (very poor).

Rostellaria ? pennata Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 20.

Anchura pennata Conrad, 1868, Cook's Geol. of New Jersey, p. 729.

? *Rostellaria compacta* Whitfield, 1892, Mon. U. S. Geol. Survey, vol xviii, p. 108, pl. xiii, figs. 18-21.

? *Rostellaria spirata* Whitfield, 1892, *Ibidem*, p. 109, pl. xiii, figs. 16, 17.

Anchura pennata Whitfield, 1892, *Ibidem*, p. 115, pl. xiv, figs. ? 7, ? 8.

? *Anchura (Drepanochilus) compressa* Whitfield, 1892, *Ibidem*, p. 117, pl. xiii, figs. 22-25.

Anchura pennata Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 22.

? *Rostellaria compacta* Johnson, 1905, *Ibidem*, p. 23.

? *Rostellaria spirata* Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 23.
Anchura pennata Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 711, pl. lxxxi, figs. 10-17 (*? ex parte*).

Description.—" Shell elevated, with about six convex volutions, and with obscure, oblique, longitudinal costæ or undulations; body whorl ventricose; labrum expanded, sinuous."—Morton, 1834.

Type Locality.—Prairie Bluff, Alabama.

" Shell elongate, spire elevated and consisting of from six to seven volutions, which are only moderately convex between the suture lines, the latter being well marked but not deep; apical angle not more than 30°, but often less; last volution proportionally large and with a somewhat extended rostral beak, slender and straight; lip broadly expanded and extended in a narrow border along the side of the beak to a point opposite the base or swell of the volution, where it rapidly widens out into the broad wing-like lip, which reaches somewhat over the next volution above but apparently not forming a posterior canal. The outer posterior angle of the expanded portion is prolonged into a narrow, recurved falciform process of greater or less extent; volutions marked by oblique longitudinal folds, which extend from suture to suture on all the upper volutions, but become obsolete just above the middle on the body portion of the last one, and are entirely obsolete on the back of the expanded lip. On the upper volutions the folds are closely arranged, but on the lower they are more distant and more strongly marked, while on the body part of the last one they are quite strong and almost node-like, even on many of the internal casts."—Whitfield, 1892.

Anchura pennata (Morton) is another specific name which, given originally to a poorly preserved and wretchedly figured cast, now covers a curious assemblage of casts and shells. Whitfield figured under the name of *pennata* two shells with the wing characters more or less perfectly preserved. He also established three apparently closely related species on inside casts, all of which are included by Weller under the name *pennata*. It seems hardly probable that the two shells which Whitfield figured are specifically identical. Figure 6 indicates a shell with more straight-sided whorls, more numerous, approximately sixteen, less oblique,

and more persistent axials, and a more quadrate wing than that suggested by figure 8. The broadly rounded tapering whorls and the relatively few, approximately twelve, axials of figure 8 corerspond more closely with the characters implied by Morton's wretched figure than do the straight whorls and numerous axials of figure 7. It is perfectly possible, to be sure, that neither one of the figures represents Morton's species, and it is highly improbable that they both do. Until further light is brought to bear upon the subject in the way of further collections from Morton's type locality at Prairie Bluff, Alabama, it seems permissible to tentatively unite the southern cast which served as Morton's type and the New Jersey shell figured by Whitfield. A new name should be given to the second figured shell under the same name, but as this does not occur in the area under discussion, that may be left for the present in the hope that further data may be available when it is necessary that the form should bear a name. It is probable that both the more rounded and the more angular shells are represented in the species of casts, *Rostellaria spirata* being allied with the more rounded type, *Anchura compressa* with the more angular, and *Rostellaria compacta* probably distinct in part (figs. 18, 19), and in part (figs. 20, 21) referable to the shell illustrated in figure 7.

There is something peculiarly unsatisfactory and disheartening in trying to straighten such a tangle of shells and casts, for the range of variation of a species should be established, wherever possible, from well preserved shells—from the radulæ, the biologist would maintain—and until this has been done, there is no way of knowing with any degree of certainty whether or not the casts and the shells are all distinct or all identical, and the only result of such an investigation may be a further confusion of the nomenclature which must be perpetuated in the future synonymies. It may, however, function as a warning to recognize the limitations of poorly preserved specimens and serve as an argument against any attempt to characterize forms which have no characters preserved, unless indeed the stratigraphic significance of the form demands its recognition.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, mouth of Turner's Creek, on the Sassafras River, Cecil County; Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey. *Selma Chalk.* *Exogyra costata* zone, Prairie Bluff, Alabama.

ANCHURA HEBE (Whitfield) Weller

Rostellaria hebe **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 111, pl. xiv, figs. 11-14.**

Anchura abrupta **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 715, pl. lxxxii, figs. 5, 6** ***(ex parte).***

Description.—" Shell moderately large, with an elongated conical spire and rather short body whorl; volution strongly rounded in the cast, number unknown but probably seven or more, the last one proportionately larger and more ventricose than any of the others; base short but somewhat extended near the columellar cavity, which is rather large, showing the axis to have been strong; upper part of the body volution largest and the lower part rounded obconical, slightly extended below; aperture, as shown by the cast, of but moderate size, narrowly elliptical in form, being nearly equally curved on the outer and inner sides; the outer side a little the more strongly so; upper and basal angles of the aperture acute; the upper one extended upon the preceding volution, causing the last volution, as it approaches the aperture, to overlap that one somewhat as in many of the *Strombidæ.* Columella smooth, without folds or ridges of any kind; suture between the coils of the cast strong and deep, but separated by only a narrow space, showing the shell at this part to have been thin; the surface of the shell has been marked by spiral bands of considerable width, but their number is not determinable from the specimens at hand; there is, however, evidence of a quite strong one near the center of the volutions, and indications of several others, especially on the basal portion of the last volutions, but not presenting any angulation as in *Anchura.*"—Whitfield, 1892.

Type Locality.—Mullica Hill, New Jersey.

This species is the largest and the most inflated species of the genus within the confines of Maryland and Delaware. The shell characters are

not known, but there is little reason to suppose that Weller was warranted in uniting these large, convex casts with Conrad's smaller and less inflated type.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, Cecil County.

Collections.—Maryland Geological Survey, Columbia University.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

ANCHURA PERGRACILIS Johnson

Anchura sp? **(young) Johnson, 1898, Ann Rept. Geol. Survey of New Jersey for 1897, p. 264.**

Anchura? pergracilis **Johnson, 1898, Proc. Acad. Nat. Sci., Phila., p. 463, text fig. 2.**

Anchura pergracilis **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 22.**

Anchura pergracilis **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 713, pl. lxxxi, figs. 18, 19.**

Description.—"Shell fusiform, whorls convex, the body whorl with about eighteen and the spiral wohrls with fifteen equidistant, flexuous, longitudinal ribs; numerous fine, revolving lines, more prominent between the ribs and somewhat obsolete on the angles of the ribs, cover the entire shell; suture deeply impressed. The length of the largest specimen (including the two apical whorls, which are wanting) is about 20 mm."—Johnson, 1905.

Type Locality.—Mount Laurel, New Jersey.

Anchura pergracilis Johnson is well characterized by its relatively small size, very slender outline, and numerous, sigmoidal costæ.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Magothy Formation.* ? Cliffwood clay, New Jersey. *Matawan Formation.* Woodbury clay, New Jersey.

ANCHURA (?) MONMOUTHENSIS n. sp.

Plate XV, Figs. 2, 3

Description.—Shell rather large, quite heavy, multispiral, whorls of the spire feebly inflated in the cast, the body whorl relatively high with

rather straight sides and quite abruptly constricted at the base into a slender and probably rather produced anterior canal; surface sculpture known only from a fragment of the exterior retained at the base of the body and from the axial ribbing upon the cast of the ultima; all trace of costals lost upon the whorls of the spire, but four feeble and four rather strong costæ developed upon the body, the third from the aperture being the strongest; fragment of outer surface very finely sculptured reticulately, the spirals low, flattened fillets separated by channels of approximately the same width, overriding the very fine and feeble secondary riblets; sutures apparently deep, whorls quite widely separated in the cast; aperture elliptical; outer lip arcuate, inner lip excavated, non-plicate.

Dimensions (of imperfect specimen).—Altitude 46 mm., maximum diameter 31 mm.

The cast in question suggests *Anchura compacta* Whitfield, but differs from it in the relatively higher body.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

Suborder STREPTODONTA

Superfamily PTENOGLOSSA

Family SCALIDAE

Genus EPITONIUM Bolten

[Museum Boltenianum, 1798, p. 91]

Type.—*Turbo scalaris* Linné.

Shell polished, turriculate, perforate or imperforate; whorls numerous, convex, often very loosely coiled; sculpture dominantly axial, axial flanges and varices often very prominent, usually continuous, and fused at the suture, in many species forming the only points of contact between the whorls; aperture subcircular or ellipsoidal; peristome entire, thickened, reflected.

Etymology: ἐπιτόνιον, a tuning wrench.

"Eighteen years ago I discussed the synonymy of these shells and showed that if the rules of the British Association, as originally promulgated, were followed we would have to call the wentle traps by the name *Cyclostoma* Lamarck. If we overlook the absence of a diagnosis, as is now generally accepted as allowable, Bolten's name *Epitonium* is available. The anonymous *Scala* appeared in a sale catalogue which indicated no publisher, and if we continue to use it we can do so only by disregarding the rules. This is probably inadvisable, as the break with the irregular nomenclature would have to come sooner or later, and it is probably best to have it over and done with. If we do not do so, the evil day is only postponed."—W. H. Dall.[1]

The genus has been gradually increasing in prominence since the Triassic and is represented in the Recent seas by some one hundred and fifty to two hundred species of "wentle trap" distributed from the polar seas to the tropics and from between tides to abysmal depths.

A. Axial costals less than eighteen to the whorl....*Epitonium marylandicum*
B. Axial costals more than eighteen to the whorl........*Epitonium cecilium*

EPITONIUM MARYLANDICUM n. sp.

Plate XVII, Fig. 7

Description.—Shell of moderate size for the genus, the whorls probably quite numerous and increasing very gradually in size, those of the spire convex and constricted at the sutures; the body whorl obtusely angulated at the base; early whorls broken away and the apical characters lost; external surface ornamented with about sixteen acutely angulated, varicose costals, separated by symmetrically concave intercostals strongest upon the medial portion of the whorl and evanescent on the base; both costal and intercostal areas incised by linear spirals equisized and equispaced, twelve in number on the posterior and medial portions of the whorl; basal sculpture obscure, probably three moniliform spirals in the peripheral region separated by slightly wider interspirals intercalated with finer secondaries, and toward the umbilical region three or four additional

[1] Prof. Paper, U. S. Geol. Survey, No. 59, 1909, p. 52.

liræ of secondary prominence; aperture subcircular, peristome continuous; umbilicus probably closed in fresh specimens by the reflected inner lip.

Dimensions.—Altitude of ultima and penultima 10.7 mm., maximum diameter 8.6 mm.

The Maryland species strongly suggests the species which Whitfield described from a Monmouth cast under the name of *Turricula scalariformis*. The spiral sculpture seems coarser and the base of the body is apparently more angulated in the New Jersey form.

The characters of the aperture of Whitfield's species are not known, in fact, the condition of the unique type is such that Whitfield apologized for its introduction into the literature.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

EPITONIUM CECILIUM n. sp.

Plate XV, Figs. 11, 12

Description.—Constituent whorls subcircular in cross-section, coiled so that they are barely in contact, probably numerous and very gradually diminishing in size toward the apex; external surface ornamented with heavy laminar varices, about twenty-one to the whorl, equal in size and perfectly regular in arrangement; aperture holostomous, circular; characters of outer lip not preserved.

Imperfect as this *Epitonium* is, a description has been offered because it is an unusually well characterized species occurring in a locality where the chances of finding perfect specimens are exceedingly poor.

The species suggests *E. annulatum* Morton, but the whorls are more rounded and less rapidly increasing in size. From *E. marylandicum* it is separated by its more rounded whorls, looser coiling and finer ornamentation.

Occurrence.—MONMOUTH FORMATION. Sassafras River, Kent County.

Collection.—Maryland Geological Survey.

Genus PSEUDOMELANIA Pictet and Campiche

[Mat. Pal. Suisse, ser. vi, 1862, p. 266]

Type.—*Chemnitzia normaniana* d'Orbigny.

Shell rather heavy, elongate-conic; whorls quite numerous, flattened, the sides of the spire converging evenly toward the apex and little or not at all interrupted at the suture lines; external sculpture not developed; sutures not channelled; body whorl smoothly rounded at the base; aperture rather small, lobate, peristome discontinuous, angulated behind, evenly rounded in front; outer lip thin, smooth; inner lip concave, reinforced but not plicate; umbilicus imperforate.

Pseudomelania is one of the most typical of Mesozoic genera. It was initiated in the Trias and has been found at almost every horizon in the entire Mesozoic, but apparently did not survive its close. The genus has not been reported in any considerable numbers from this country, although it is very abundant abroad. It is probable that a number of the species referred to *Eulima* would find their true affinities with this genus.

PSEUDOMELANIA MONMOUTHENSIS n. sp.

Plate XVI, Fig. 10

Description.—Shell of moderate size for the genus, thin, highly polished, elongate-conic in outline; whorls probably eight or ten in all, flattened laterally, decreasing very slowly in size and converging at an angle of $\pm$ 15°; sutural channels concealed by a thin glaze which is frequently broken away; body whorl obscurely carinated at the periphery, obliquely constricted at the base; aperture obliquely lobate, angulated behind, rounded in front, the labral convexity a little higher than the labial concavity; columella feebly reinforced; parietal wall free from glaze.

Dimensions.—Altitude $\pm$ 10 mm., maximum diameter 2.8 mm.

The type is unique, but at least it is sufficient to definitely establish the presence of this genus in the Upper Cretaceous deposits of Maryland.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Etymology: ψευδής, false; *Melania*, a genus of gastropods.

Family CERITHIIDAE

Genus CERITHIUM Bruguière

[Encycl. Méth., pt. ii, 1792, p. 467]

Type.—*Murex aluco* Linnæus.

Shell rather thick and heavy; imperforate, multispiral; outline turrito-conic, the whorls of the spire usually more or less flattened laterally and regularly increasing in size; external sculpture ornate, often varicose or nodulated; sutures distinct, closely appressed; aperture obliquely lenticular, produced somewhat posteriorly, and terminating anteriorly in a short, recurved, often truncate canal; outer lip more or less expanded, and thickened within; inner lip excavated, usually with a denticle near the posterior commissure and one or two plications near the anterior margin; parietal wash very heavy.

Cerithium originated before the middle of the Mesozoic, and culminated in the Eocene. The recent species, however, constitute one of the major factors in the littoral and brackish water faunas of the temperate and tropical seas.

CERITHIUM PILSBRYI Whitfield

Cerithium pilsbryi Whitfield, 1893, Nautilus, vol. vii, pp. 38 and 51, pl. ii, fig. 3.
Cerithium pilsbryi Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 22.
Cerithium pilsbryi Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 708, pl. lxxxi, figs. 3-5.

Description.—" Shell elongated and slender; volutions numerous, number not determined, very gradually expanding with additional growth; apex and aperture unknown. Volutions slightly convex between the sutures, and ornamented by a band of small oblique nodes immediately below the suture; also by a series of larger vertical folds which extend across the exposed part of the volution, below the upper band of nodes, and numbering something more than half as many to the volution as the nodes above. There are also very fine spiral striæ, almost too fine to be seen without magnifying. The lines of growth are fine but distinct, and

Etymology: Κεράτιον, a little horn.

take a broad sweeping backward curve below the sutures; apical angle fifteen to eighteen degrees."—Whitfield, 1893.

Type Locality.—Lenola, New Jersey.

Until the characters of the aperture are known the generic affinities cannot be determined with any assurance. The single imperfect cast from the area under discussion contributes nothing to the knowledge of the form.

The major axial nodes number ten to twelve to each of the later whorls.

Occurrence.—MATAWAN FORMATION. Chesapeake and Delaware Canal (exact locality not known).

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—MATAWAN FORMATION. Merchantville clay marl, New Jersey.

Family VERMETIDAE

Genus SERPULORBIS Sassi

[Giorn. Ligustica, vol. v, 1827, p. 482]

Type.—*Serpulorbis polyphragma* Sassi = *Serpula arenaria* Linné (*ex parte*) = *Vermetus gigas* Gray.

Tubes large, as a rule, and irregularly contorted; external surface usually lirate and often more or less granulose; internal longitudinal laminæ not developed; transverse partitions or pouches frequently present; non-operculate.

The recent species occur in considerable numbers in the warmer waters.

? SERPULORBIS MARYLANDICA n. sp.

Plate XVII, Figs. 8, 9

Description.—Type of two component tubes equal in size and increasing in diameter with equal rapidity; each surrounded by a discrete calcareous layer, fused along the line of contact of the tubes into a single shelly covering; tubes performing about one and a half volutions, superimposed one above the other at the beginning of the coil, but tending toward a

Etymology: *serpula*, a little serpent; *orbis*, a circle.

lateral contact near the anterior extremity, coiled in such a plane that the upper of the tubes is in contact at the aperture with the lower of he preceding volution; external surface smooth; cross-section of apertures circular.

The species is doubtless similar in composition to the form described by Conrad under the name of *Diploconcha*. The fusing of the constituent tubes along the contacts is a common phenomenon in the recent gregarious *Vermetidæ* and is a character of no systematic value whatever.

The species suggests *S. rotula* Weller, but is larger and less regularly coiled.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Genus VERMETUS Adanson

[Hist. Nat. Sénégal, 1757, p. 160]

Type.—*Vermetus adansoni* Daudin.

Shell usually fixed, rarely free; regularly coiled in the young of some species, loosely and irregularly twisted in the adults of all; internal septæ usually present; aperture circular; majority of species operculate.

VERMETUS CIRCULARIS (Weller)

Serpula circularis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 307, pl. xix, figs. 5, 6.

Description.—" Tube rather large, moderately thick, increasing gradually in size, the increase being more rapid as it approaches the aperture, not closely coiled, the first volution of the type specimen forming a rather large irregular circle, after which the shell is in contact for about one-fourth volution nearly to the aperture. Another specimen is perhaps not in contact at all. Aperture more or less subcircular or subelliptical in outline. The surface of the shell is marked by more or less irregular, annular lines of growth. The dimensions of the type species are: Greatest diameter of aperture, 8 mm.; length of tube, 72 mm.; greatest diameter of space within first volution, 13 mm."—Weller, 1907.

Etymology: *Vermis*, a worm.

A fragment was collected from the Monmouth which suggests Weller's species. The external surface of the Maryland form, however, is sculptured with probably about half a dozen longitudinal ridges. The species has more of the general aspect of *Vermetus* than of an annelid, and although no evidence of internal septæ is attainable there is some reason to believe that the shell was made up of three component layers instead of two as in the tubiculous annelids. Other tubes apparently new but too imperfect to describe occur in the Matawan of Anne Arundel County. They are smaller and straighter than the tubes from the Monmouth and often more or less compressed laterally.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Genus LAXISPIRA Gabb

[Proc. Acad. Nat. Sci., Phila., 1876, p. 301]

Type.—*Laxispira lumbricalis* Gabb.

" Shell spiral, dextral, whorls with a circular cross-section, few in number, and so rapidly descending as to form an open spiral; aperture simple, lips thin.

" A curious genus, the relations of which are not clear to me. I propose it to receive some shells which have been long known as internal casts in the marls of New Jersey, but of which the surface was unknown until quite recently. In general form they might be compared to a partially uncoiled *Turritella*. From that genus they differ, however, in the whorls not being in contact, and from *Vermetus* and the allied genera in being regular spirals, but not having the apex either turritelloid or attached." —Gabb, 1876.

Dall[1] considers the genus as a synonym of *Siliquaria*, but the coiling is conspicuously regular, more so than in any known species of *Siliquaria*. For that reason it seems desirable to keep the two groups distinct until evidence is produced which demands their union.

Etymology: *Laxus*, loose; *spira*, spire.

[1] Trans. Wagner Free Inst. Science, Phila., 1892, vol. iii, pt. ii, p. 307.

LAXISPIRA LUMBRICALIS Gabb

Laxispira lumbricalis Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 301, pl. xvii, figs. 6, 7.

Laxispira lumbricalis Tryon, 1883, Struct. and Syst. Conch., vol. ii. p. 309, pl. lxxix, fig. 14.

Laxispira lumbricalis Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 148, pl. xviii, fig. 25.

Laxispira lumbricalis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 22.

Laxispira lumbricalis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 706, pl. lxxxi, figs. 1, 2.

Description.—" Shell with a circular cross-section, whorls about as far apart as the diameter of the whorls, three or four in number; surface marked by numerous small, closely placed revolving ribs."—Gabb, 1876.

Type Locality.—Haddonfield, New Jersey.

" The dimensions of a large specimen, an internal cast, are: Height 29 mm., maximum diameter 12.5 mm., apical angle about 28°, number of volutions about 4½, height of aperture 8.5 mm., width of aperture 6.3 mm. Shell forming an open spiral, in which the volutions are not in contact, the sutural space in the casts being nearly as wide as the diameter of the volutions. Cross-section of the volutions nearly circular, except in the outer volution of mature shells, in which, near the aperture, the shell is slightly compressed, making the aperture higher than it is wide and straighter on the inner than on the outer lip. Surface of the shell marked with fine, raised, revolving lines, from two to four of which occupy the space of 1 mm., and by transverse lines of growth."—Weller, 1907.

The species is so well characterized by the lirated loose coil that even the fragments which represent the species in Delaware can be determined with assurance.

Occurrence.—MATAWAN FORMATION. Post 218, Post 105, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Woodbury clay, New Jersey. *Ripley Formation. Exogyra costata* zone, Union and Tippah counties, Mississippi.

Family TURRITELLIDAE

Genus TURRITELLA Lamarck

[Prodrome, 1799, p. 74]

Type.—*Turbo terebra* Linné.

A slender, polygyrate form spirally sculptured; aperture holostomous, oval or subquadrangular; outer lip thin, simple, slightly produced anteriorly; columella simple, concave; posterior portion of shell vacant and partitioned at each half turn.

Turritella originated quite early in the Mesozoic and before the end of the Cretaceous had become one of the more conspicuous elements in the gastropod faunas of North America. The culmination of the genus occurred, however, during the Tertiary, when it was represented by a large number of very prolific species. The representation in the recent seas is relatively meager, and confined, for the most part, to the warmer waters of the Old World.

A. Primary spirals more than three in number.
  1. Altitude of adult shell not exceeding 30 mm.; primary spirals fine and crowded; the secondaries microscopically fine.
    a. Later whorls convex; primaries usually five or six in number .... *Turritella bonaspes*
    b. Whorls flattened; primaries twelve to fifteen in number. *Turritella delmar*
  2. Altitude of adult shell exceeding 30 mm.
    a. Primary spirals low, flattened, usually five in number, separated by interspirals of equal or greater width; whorls convex, in the casts loosely coiled with well-rounded sutural channels.................... *Turritella paravertebroides*
    b. Spirals approximately ten in number, subequal in size and spacing; whorls closely coiled, acutely angulated at the sutures .... *Turritella encrinoides*
B. Primary spirals three in number, very prominently elevated.
  1. Primaries sharp, laminar, very prominently elevated ridges, equal in size and symmetrically spaced; secondaries microscopically fine.................................. *Turritella trilira*
  2. Primaries cordate.
    a. Primaries asymmetrically spaced with respect to the sutures; secondaries fine but not microscopic........ *Turritella tippana*
    b. Primaries symmetrically spaced with respect to the sutures; secondaries only a little finer than the primaries. *Turritella encrinoides*

Etymology: Diminutive of *turris*, tower.

TURRITELLA BONASPES n. sp.

Plate XVII, Fig. 10

Turritella (?) sp. **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, pl. lxxix, figs. 8, 9.**

Description.—Shell rather small for the genus, and quite slender; whorls probably about ten in number, the early volutions quite feebly, the latter evenly concave, and slightly overhanging the suture; apical angle not exceeding 12°; axial sculpture not developed; spiral sculpture on the later turns of fine, flattened, primary liræ, with intercalated, linear secondaries, and between the posterior primary and the suture, two spirals midway in prominence between the primaries and the secondaries; suture lines deeply impressed, the posterior margin almost horizontal, the anterior slope about 45°; characters of base unknown.

Dimensions.—Altitude± 20 mm., maximum diameter 5 mm.

This species strongly suggests *T. jerseyensis* Weller of the Magothy of New Jersey, and may quite possibly prove to be identical with that species. However, Weller makes no mention of the development of any intercalated secondaries nor of the two liræ between the posterior spiral and the suture. The secondaries are exceedingly fine and may have been obliterated in the New Jersey form. Perhaps the most striking similarity in the two shells is in the relatively loose coiling and consequent deepening of the sutural channel in the later whorls. It is very abundant at the type locality but has not been recognized elsewhere.

Occurrence.—MAGOTHY FORMATION. Good Hope Hill, District of Columbia.

Collection.—Maryland Geological Survey.

TURRITELLA DELMAR n. sp.

Plate XVII, Figs. 3, 4

Description.—Shell small for the genus; elongate-conic, not conspicuously slender; whorls flattened, probably not more than ten in number, converging at an angle of 12°; spiral sculpture very fine and crowded, the liræ subequal, twelve to fifteen in number on the later turns; fortuitous

secondaries intercalated; interspiral areas linear; sutures quite deeply impressed, the posterior slope of the sutural channel steeper than the anterior; periphery of body whorl obtusely carinate; sculpture of base similar in strength and character to that upon the sides of the whorl.

Dimensions.—Altitude 13.5 mm., maximum diameter 4.5 mm.

In the casts the earlier whorls are broadly rounded and quite distant, but the later volutions are obtusely angulated and proximate.

The species is very abundant at the type locality, and was at first mistaken for *T. encrinoides* juvenis. The spirals are much more uniform in size, however, and the whorls more obscurely angulated in the casts.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal.

Collection.—Maryland Geological Survey.

TURRITELLA PARAVERTEBROIDES n. sp.

Plate XVII, Fig. 1

Description.—Shell elongate-turrited, the whorls flattened, probably fourteen or fifteen in number, regularly increasing in size, converging at an angle of approximately 20°; axial sculpture not developed; spiral sculpture uniform in character over the entire surface of the shell, primaries normally five in number, though occasionally one more or less, well rounded moderately elevated cords, subequal in size and spacing at least upon the anterior half of the whorl, often more distant and less prominent upon the posterior; inter-spiral areas flattened; entire surface overrun with microscopically fine crowded striæ, six to eleven in number on each of the inter-spiral areas of the later whorls; suture line impressed, placed nearer the posterior spiral than the anterior of the preceding turn; the posterior slope of the sutural channel steeper than the anterior; body whorl obtusely carinated at the periphery; the base flattened and microscopically striate.

This species, like most of the group, shows a wide range in variation. There is quite a little difference in the relative strength of the spirals, although they never approach in sharpness the primaries of the true

vertebroides. The second in front of the posterior suture is usually a little stronger than the rest and in the immature individuals the first spiral in front of the posterior suture is feeble or undeveloped.

Turritella paravertebroides is apparently the analogue in Maryland of the abundant and characteristic *vertebroides* of the Gulf and New Jersey. It differs most conspicuously from Morton's well-known species in the more subdued sculpture. The primary spirals are never so sharply elevated, and, unlike *vertebroides,* they are relatively more prominent upon the posterior portion of the whorl. The secondary sculpture is finer and more regular, the whorls are less constricted at the sutures, the periphery of the body is not acutely carinated, nor is it outlined by a prominent spiral, and the base is striated though faintly so. Weller[1] figured a second specimen which has not been described, apparently, although it is widely distributed, not only through New Jersey but the Gulf as well. From this unnamed form *T. paravertebroides* differs in its rather larger size, more flattened whorls, sculptured apical region, the broader primaries with numerous intercalated secondaries and a less strongly lirated base.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

TURRITELLA TRILIRA Conrad

Turritella trilira **Conrad, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 285.**

Turritella corsicana **Shumard, 1861, Proc. Bost. Soc. Nat. Hist., vol. viii, p. 196.**

Turritella corsicana **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 18.**

Turritella trilira **Meek, 1864, *Ibidem.***

Turritella trilineata **Hill, 1901, 21st Ann. Rept. U. S. Geol. Survey, pt. vii, pl. xlvii, fig. 3.**

Turritella trilira **Veatch, 1906, Prof. Paper U. S. Geol. Survey, No. 46, pl. xi, fig. 4.**

Turritella trilira **Weller, 1907, Geol. Survey of New Jersey, Pal., p. 899, pl. lxxix, figs. 4, 5.**

[1] Rept. Cret. Pal. New Jersey, 1907, vol. iv, pl. lxxviii, fig. 14.

Description.—"Turrited; whorls with three equidistant, very acute, prominent ribs; revolving lines microscopic, closely arranged."—Conrad, 1860.

Type Locality.—Tippah County, Mississippi.

Shell turrited, large for the genus, attaining a maximum altitude of ± 80 mm. and a diameter of more than 20 mm.; whorls probably sixteen or more in number in a perfect individual, the earlier whorls flattened, the later feebly convex, converging at an angle of about 25°; external surface sculptured with three sharply and very prominently elevated laminar equisized and equilateral ridges, separated by symmetrically concave interspaces, the posterior spiral a little nearer the suture line than the anterior; interspiral areas threaded with miscroscopically fine liræ, which are minutely crenulated by the incrementals; suture lines distinct, impressed but inconspicuous by reason of the overhanging spiral ridges placed about midway on the upcurve of the interspiral between the posterior lamina and the anterior lamina of the preceding turn; interspiral areas between the laminæ of succeeding whorls scarcely wider than those between the laminæ on the same whorl; base very finely and evenly threaded; casts characterized by evenly rounded whorls, separated by rather deep sutural channels.

In a single individual from Brightseat which is doubtfully referred to this species the posterior of the three spirals is much less elevated than the two in front of it. The general contour of the shell, the character of the secondary sculpture and the position of the suture line are normal for the species, and it is impossible to determine the significance of the variation in the primaries without further material.

Occurrence.—MATAWAN FORMATION. Arnold Point on the Severn River, Ulmstead Point, Magothy River, Anne Arundel County. MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, ? Friendly, McNeys Corners, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Wenonah Sand, New Jersey. *Black Creek Formation.* North and South Carolina. *Peedee*

Sand. North and South Carolina. *Eutaw Formation* (Tombigbee Sand member). *Exogyra ponderosa* zone, *Mortoniceras* subzone, Georgia. *Exogyra ponderosa* zone, Prentiss County, Mississippi. *Ripley Formation.* *Exogyra costata* zone, Georgia; Eufaula, Alabama; Union and Tippah counties, Mississippi. *Extreme top of zone,* Pataula Creek, Georgia. *Selma Chalk.* *Exogyra costata* zone, Wilcox County, Alabama. *Brownstown* (?), *Annona, Marlbrood, Nacatoch,* and *Arkadelphia Formations.* Arkansas. *Taylor* and *Navarro Formations.* Texas.

TURRITELLA TIPPANA Conrad

Turritella tippana Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iii, p. 333, pl. xxxv, fig. 19.

Turritella tippana Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 19.

Turritella tippana Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 700, pl. lxxix, figs. 6, 7.

Description.—"Subulate; sides straight; volutions carinated with revolving lines, two on each volution larger than the others, remote, one nearly equal in size, nearly medial, and three other fine lines; whorls of spire slightly carinated at base."—Conrad, 1858.

Type Locality.—Owl Creek, Tippah County, Mississippi.

"The dimensions of a large example, incomplete at the apex, are: Height 69 mm., greatest diameter 22 mm., apical angle about 19°, number of volutions shown 10. Suture situated in the bottom of a broad, concave, revolving channel. Surface of the volutions between the margins of the sutural channel nearly flat or slightly convex; marked by four or five strong, revolving costæ, the three lower ones being subequidistant, the upper one more remote; in the broader interspace between the uppermost strong costa and the one next below is a much finer rib, and a similar one about midway on the slope from the uppermost strong costa to the suture, although this last one is sometimes strong enough, especially in the larger shells, to be counted as one of the major ribs; in each of the interspaces between the three lowermost strong costæ on the larger volutions there is frequently a much smaller raised line; and on the slope of the lowermost

one of these costæ to the lower suture, another one somewhat stronger than those in the interspaces above. The surface is also marked by very fine transverse lines of growth."—Weller, 1907.

The species has a meager representation in Maryland. It is characterized by the relatively large apical angle, and the subdued, though rather elaborate spiral sculpture.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Marshalltown marl, New Jersey. *Ripley Formation. Exogyra costata* zone, Union County, and Owl Creek, Tippah County, Mississippi.

TURRITELLA ENCRINOIDES Morton

Turritella encrinoides **Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 47, pl. iii, fig. 7.**

Turritella encrinoides **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 18.**

Turritella encrinoides **Conrad, 1868, Cook's Geol. of New Jersey, p. 729.**

Turritella encrinoides **Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 301.**

Turritella encrinoides **Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 143, pl. xviii, figs. 19-22.**

Turritella pumila ? **Whitfield, 1892, *Ibidem*, vol. xviii, p. 187, pl. xxii, figs. 5, 6. (Not *T. pumila* Gabb.)**

Turritella encrinoides **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.**

Turritella encrinoides **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 694, pl. lxxviii, figs. 10-13.**

Description.—"Of this fossil I have met with several fragments, yet scarcely perfect enough for description. I have figured one of them to show the difference between this and the former species [*T. vertebroides* Morton], as the two occur in the same strata."—Morton, 1834.

Type Locality.—? New Jersey.

"Shell acutely angular, the angle of divergence of the sides being about 20°. Suture not strongly impressed, situated in an angular, rounded furrow; surface of the volutions depressed convex, nearly flat in the central portion and curving more abruptly to the sutures above and below. Sur-

face marked by three major revolving costæ which are flattened on top; in addition to the major costæ there are lower, angular, revolving ribs siuated as follows: one between the lower suture and the first major costa, one between the first and second costæ, two between the second and third costæ, and two between the third major costa and the upper suture. In the casts the sutures are rather close, especially between the lower and larger volutions; the lower volutions are more or less quadrangular in cross-section, the upper ones being rounder, due undoubtedly to the internal thickening of the shell with age."—Weller, 1907.

Occurrence.—MATAWAN FORMATION. Opposite Post 236, Post 218, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. ? Cayots Corners, north end of Fredericktown Bridge, Cecil County, Maryland.

Outside Distribution.—Monmouth Formation. Navesink marl, New Jersey.

Family SOLARIIDAE

Genus SOLARIUM Lamarck

[Prodrome, vol. 1, 1799, p. 74]

Type.—Trochus perspectivum Linné.

Shell solid, perforate; outline subdiscoidal to depressed-conic; whorls numerous, regularly increasing in size; periphery rounded or carinate; dominant sculpture of simple or beaded spirals; aperture semi-elliptical to subquadrate; columella usually straight, simple; outer lip thin and sharp; umbilicus funicular or scalar.

Solarium was most abundant in the Eocene and the recent species, the "sun-dial" shells, are relatively few in number and are restricted to the warmer waters.

In the absence of the nuclear characters it is difficult to separate the members of this genus from those of *Euomphalus,* but it seems probable that the *Solaria* occur as early as the Jurassic.

Etymology: *Solarium,* sun-dial.

SOLARIUM MONMOUTHENSIS n. sp.

Plate XIII, Fig. 7

Description.—Shell suborbicular, spire very low and smoothly rounded, the contour not interrupted at the sutures; whorls flattened from five to six in number, regularly increasing in size; the suture lines coincident with the periphery; shell substance apparently rather heavy but decorticated so that no trace of the original sculpture is discernible; sutures quite deeply impressed; body whorl acutely angulated at the periphery, the base feebly convex near the aperture; aperture probably trigonal, although its outline is partially concealed by the silicified matrix; character of the umbilicus also concealed.

Dimensions.—Altitude 5 mm., maximum diameter 14.5 mm., diameter at right angles to maximum diameter 12 mm.

The type is the only representative of the genus in Maryland. Although it is impossible to determine with certainty the affinities of shells of this type, in which the nuclear characters and the operculum have been lost, yet the general outline suggests *Solarium* much more strongly than it does any of the *Euomphalidæ*.

Occurrence.—MONMOUTH FORMATION. Two miles southwest of Oxon Hill on Mrs. Linton's branch, Prince George's County, Maryland.

Collection.—Maryland Geological Survey.

Family XENOPHORIDAE

Genus XENOPHORA Fischer de Waldheim

[Tab. Syn. Zoogn., 1808, p. 113]

Type.—*Xenophora conchliophora* (Born).

Shell low, trochiform, but never nacreous; imperforate or narrowly umbilicate; whorls flattened, armored with agglutinated extraneous objects; base subconic, or flattened with a sharp, peripheral keel; aperture obliquely quadilateral.

The persistence of this genus from the mid-Paleozoic to the Recent bears testimony to the efficacy of the extraordinary device by which this mollusc protects itself. The bulk of the shells and pebbles carried by this

Etymology: ξένος, a stranger; φέρω, I carry.

ardent little collector is often astonishing: *Turritellæ, Cardia* an inch and a half in altitude, *Chamæ,* all are utilized by the enterprising univalve. It is by no means uncommon among the recent forms for the diameter of the shell to be doubled by the load that it carries.

XENOPHORA LEPROSA (Morton) Whitfield

Trochus leprosus Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 46, pl. xv, fig. 6.

Phorus leprosus Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 18.

Onustus leprosus Conrad, 1868, Cook's Geol. of New Jersey, p. 728.

Xenophora leprosa Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 135, pl. xvii, figs. 16-19.

Xenophora leprosa Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.

Xenophora leprosa Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 690, pl. lxviii, figs. 1-3.

Description.—" Compressed; spire composed of about four volutions, presenting an unequal, rugged surface. Diameter from an inch to an inch and a half."—Morton, 1834.

Type Locality.—Prairie Bluff, Alabama.

" Shell small or below a medium size, trochiform, or broad conical; the spire having an apical angle of less than 90°; base flat or concave, usually more or less depressed in the center, with the margin of the volution more or less rounded, and in old individuals sometimes distinctly rounded; casts showing a small umbilical perforation, but the axis probably solid in the shell; volutions probably seven or eight, but in the casts the upper ones are usually absent and seldom show more than four or four and a half; one small specimen retaining the upper whorls, to the number of four and a half, measures only five-eighths of an inch in diameter. This one, if continued below to the size of the larger one figured, would possess at least eight volutions; whorls obliquely flattened on their surfaces in the direction of the spire, with only a small portion of their edges rounded or vertical, and the surfaces deeply and abundantly scarred by the cicatrices of foreign substances which have been attached to the surface of the shell during life; aperture compressed, transversely ovate or trapezoidal, and the outer margin much prolonged."—Whitfield, 1892.

The only evidence of the former existence of this species within the area under discussion is a single cast from along the Chesapeake and Delaware Canal.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey. *Selma Chalk.* Wilcox County, Alabama; east-central Mississippi.

Family NATICIDAE

Genus GYRODES Conrad

[Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, 1860, p. 289]

Type.—*Natica* (*Gyrodes*) *crenata* Conrad.

Shell very thin, low, subglobose, whorls flattened posteriorly. Sutural channel developed in a greater or less degree, the outer margin of the channel usually wrinkled or crenulate. External sculpture not present upon the periphery of the whorl. Aperture obliquely ovate. Both labrum and labium thin; umbilicus usually wide, uniformly deep and free from callus.

The diagnostic characters of *Gyrodes* are the thin shell, the depressed globose whorls, the frequently crenate sutural channel margin and the deep and open umbilicus.

A. Whorls oblique, asymmetrically rounded, outer margin of sutural channel acutely angulated......................*Gyrodes petrosus*
B. Whorls erect, symmetrically rounded, outer margin of sutural channel acute......................................*Gyrodes abyssinus*

GYRODES PETROSUS (Morton) Gabb

Plate XIII, Fig. 8

Natica petrosa Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 48, pl. xix, fig. 6.

Natica alveata Conrad, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 289, pl. xlvi, fig. 45.

Gyrodes alveata Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 21.

Gyrodes petrosa Meek, 1864, *Ibidem.*

Gyrodes petrosus Conrad, 1868, Cook's Geol. of New Jersey, p. 729.

Gyrodes petrosa Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 295.

Gyrodes petrosus Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 127, pl. xvi, figs. 1-4.

Etymology: γῦρος, circle; εἶδος, like.

Gyrodes petrosus Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.
Gyrodes petrosus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 689, pl. lxxvii, figs. 13-18.

Description.—" Shell depressed, convex above; whorls four, rounded; suture indented; umbilicus very patulous. Diameter an inch and one-fourth."—Morton, 1834.

Type Locality.—Prairie Bluff, Alabama.

Shell transversely elliptical in outline, depressed; whorls five in number, spire very low and tapering rapidly to the acute and rather prominent apex; later whorls narrowly tabulated, the shoulder more or less obliquely depressed, acutely angulated at its periphery; body whorl flattened in front of the shoulder, rounded medially; external surface smooth excepting for incremental scratches; sutures distinct, impressed; aperture obliquely ovate in outline, the anterior extremity produced and broader than the posterior, the outer lip thin, sharp, asymmetrically arcuate, inner lip feebly concave; umbilical area large, auriculate, the pit at its posterior extremity; umbilical margin more or less acutely angulated.

Gyrodes petrosus (Morton) is well characterized by the oblique compression of the posterior half of the whorl, the flattening and depression of the whorl in front of the suture, the angulated umbilical keel and the very much produced aperture.

Occurrence.—MATAWAN FORMATION. Post 218, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. ? Bohemia Mills, Cecil County; Brightseat, Brooks estate near Seat Pleasant, railroad cut 1 mile west of Seat Pleasant, 1 mile west of Friendly, 2 miles southwest of Oxon Hill, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Wenonah sand, New Jersey. *Monmouth Formation.* Navesink marl, Red Bank sand, New Jersey. *Ripley Formation. Exogyra costata* zone, Union and Tippah counties, Mississippi. *Selma Chalk. Exogyra costata* zone, Wilcox County, Alabama; east-central Mississippi.

GYRODES ABYSSINUS (Morton) Gabb

Natica abyssina Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 49, pl. xiii, fig. 13.

Gyrodes abyssinis Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 295.

Natica abyssina Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 123, pl. xv, figs. 9-12.

Natica abyssina Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.

Gyrodes abyssina Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 683, pl. lxxvii, figs. 7-9 *(ex parte)*.

Description.—" Shell with a flattened spire; suture channelled; body whorl large, obtusely rounded; umbilicus patulous; aperture not expanded, longitudinally elliptical. Diameter three-fourths of an inch."—Morton, 1834.

Type Locality.—Prairie Bluff, Alabama.

" Shell large, globose, with a flattened spire, the inner volutions of which scarcely rise above the outer ones, and are only two and a half to three in number; volutions rather ventricose and erect, ovate in a transverse section; umbilicus large and open to near the apex of the shell; aperture ovate, two-thirds as wide as long, and a little more convex on the outside than on the inner margin, nearly equally rounded above and below; suture well marked and deeply impressed."—Whitfield, 1892.

Gyrodes abyssinus Morton has a meager representation in Maryland and the specimens referable to it are in very poor condition. The species seems about the same size as *G. petrosus,* but is much more erect than the latter and does not exhibit any of the characteristic obliquity of *G. petrosus.* It has, furthermore, a much more symmetrically rounded body, a deeper sutural channel and a more rounded umbilical margin.

Occurrence.—MONMOUTH FORMATION. Two miles west of Delaware City on John Higgins farm, Delaware; Bohemia Mills, Cecil County: mouth of Turner's Creek, Kent County; Brooks estate near Seat Pleasant, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey. *Eutaw Formation* (Tombigbee sand member). *Exogyra pon-*

derosa zone, *Mortoniceras* subzone, Perry and Dallas counties, Alabama. *Transition Beds, Eutaw to Selma.* Dallas County, Alabama. *Ripley Formation. Exogyra costata* zone, Chickasaw and Union counties, Mississippi. *Selma Chalk. Exogyra ponderosa* zone, east-central Mississippi. *Selma Chalk. Exogyra costata* zone, Wilcox County, Alabama; east-central Mississippi.

Genus POLYNICES Montfort
[Conch., vol. ii, 1810, p. 222]

Type.—*Nerita mammilla* Linné.

The shell characters of *Polynices* are very similar to those of *Natica;* it differs, however, in the possession of a corneous, rather than a calcareous operculum. The genus, though of later origin than *Natica,* is much more abundantly represented in the middle and late Tertiaries and in the East Coast waters of to-day, and constitutes, indeed, one of the most conspicuous elements of the univalve faunas of eastern North America.

Subgenus EUSPIRA Agassiz
[Sowerby, Min. Conch., German ed., 1842, p. 140]

POLYNICES (EUSPIRA) HALLI (Gabb)
Plate XIII, Figs. 1, 2

Lunatia halli Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 391, pl. lxviii, fig. 11.
Lunatia halli Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 20.
Lunatia halli Conrad, 1868, Cook's Geol. of New Jersey, p. 729.
Lunatia halli Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 130, pl. xv, figs. 13-16.
Lunatia halli Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.
Lunatia halli Weller, 1907, Rept. Cret. Pal. New Jersey, vol. iv, p. 677, pl. lxxvi, figs. 11-14 (synonymy and figs. 9, 10, 15-19 excluded).

Description.—" Elongated, subglobose, spire high; whorls five, rounded and angulated above; mouth elliptical, umbilicus open; surface smooth or minutely wrinkled."—Gabb, 1860.

Type Locality.—New Jersey.

Etymology: *Polynices*, a son of Œdipus.

Shell of moderate size, rather heavy but not very stout, whorls five or six in number, regularly increasing in size, evenly but not strongly inflated, obtusely shouldered posteriorly; aperture a little more than one-half and body whorl a little more than three-fourths the total altitude; external surface smooth excepting for incremental scratches; aperture semi-elliptical to ovate, the outer margin strongly arcuate, patulous anteriorly, the maximum expansion a little in front of the medial line; inner margin slightly concave; umbilical pit small.

The synonymy of this species is in a well-nigh hopeless state of confusion. The type of the species is a cast from the Monmouth of New Jersey. Weller has included under this species a series of relatively lower, less inflated forms from the Matawan which seem too distant to be included even within the wide limits of sex variation in outline of this group.

This species is a much less inflated shell than either *Natica obliquata* Hall and Meek, or *Natica concinna* Hall and Meek.

Occurrence.—MONMOUTH FORMATION. Railroad cut 1 mile west of Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Wenonah sand, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey.

POLYNICES (EUSPIRA) ALTISPIRA (Gabb)

? *Lunatia altispira* Gabb, 1862, Proc. Acad. Nat. Sci., Phil., for 1861, p. 320.
? *Gyrodes obtusivolva* Gabb, 1862, *Ibidem.*
***Lunatia* ? *altispira* Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 20.**
***Gyrodes* ? *obtusivolva* Meek, 1864, *Ibidem*, p. 21.**
***Lunatia altispira* Conrad, 1868, Cook's Geol. of New Jersey, p. 729.**
Gyrodes obtusivolva* Conrad, 1868, *Ibidem.
***Lunatia obtusivolva* Conrad, 1869, Am. Jour. Conch., vol. v, p. 45, pl. i, fig. 11.**
***Gyrodes obtusivolva* Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 129, pl. xvi, figs. 9-12.**
***Gyrodes altispira* Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.**
Gyrodes obtusivolva* Johnson, 1905, *Ibidem.
***Gyrodes altispira* Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 687, pl. lxxvii, figs. 19-21.**

Description.—"Elevated subglobose. Spire rather high; whorls four, rounded, abruptly truncated or concave above. Body whorl gibbous. Mouth broad, rounded. Umbilicus (in casts) small, perforated rather deeply. No markings on the casts. Length 0.8 in., width of body whorl 0.7 in., length of mouth 0.6 in."—Gabb, 1862.

Type Locality.—New Jersey.

The species is known in Maryland only in the form of poorly preserved casts characterized by tabulated shoulders, angular shoulder keel, well rounded body and very small umbilicus.

The very small umbilical area and pit indicate *Euspira* rather than *Gyrodes.*

Occurrence.—MATAWAN FORMATION. Arnold Point, Severn River, Anne Arundel County. MONMOUTH FORMATION. ? Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey.

Family EUOMPHALIDAE

Genus DISCOHELIX Dunker

[Palæont. ser. I, vol. 1, 1847, p. 132]

Type.—*Discohelix calculiformis.*

Shell discoidal, depressed, the apical surface flattened or slightly concave, the dorsal surface widely umbilicate; whorls rectangular in cross-section, the peripheral keels acute and either simple or nodulose; aperture quadrate.

The classification of these depressed, turbinate and discoidal forms is very uncertain. The typical Paleozoic *Euomphalidæ* are separated from the typically Tertiary and Recent *Solariidæ* on the characters of the nucleus which in the former is dextral and in the latter sinistral. Both families are represented in the Mesozoic, and rarely by specimens which have preserved their nuclei. For that reason the systematic work upon these groups has been unusually difficult and unsatisfactory.

Etymology: δίσκος, disc; ἕλιξ, spiral.

Discohelix has been reported from strata as old as the Trias and from strata as young as the Oligocene. The type species was described from the Lias.

DISCOHELIX LAPIDOSA (Morton)

Delphinula lapidosa Morton, 1834, Synop. Org. Rem. Cret. Group U. S., p. 46, pl. xxx, fig. 7.

Delphinula lapidosa Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 152, pl. xvii, figs. 9-11.

Straparolus lapidosus Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 19.

Description.—"Shell discoidal, with about three volutions; shoulder angulated; margin flattened; umbilicus profoundly patulous; spire slightly elevated above the body whorl."—Morton, 1834.

Type Locality.—Prairie Bluff, Alabama.

This shell is unusually well characterized by its rapidly enlarging depressed whorls and flattened apical surface. It is quite widely distributed through the Upper Cretaceous of eastern North America, but is nowhere abundant.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum.

Outside Distribution.—*Ripley Formation. Exogyra costata* zone, Union County, Mississippi. *Selma Formation. Exogyra costata* zone, Kemper and Oktibbeha counties, Mississippi.

Genus AMAUROPSIS Mörch

[Moll. Gronl. Nat. Bidr. Beck's Gronl., 1857, p. 81]

Type.—*Nerita islandica* Gmelin.

Shell rather small, thin, in the recent shells covered with a conspicuous periostracum; outline ovate; spire elevated for the group; external surface smooth or feebly sculptured; sutures channelled; aperture holostomous, obovate, inner lip oblique or feebly excavated; parietal wall usually glazed; umbilicus nearly or quite imperforate; operculum horny.

Etymology: *Amaura*, a pyramidellid genus; ὄψις, form.

The genus is known to recede well back into the Mesozoic. As in a number of other ancient types, the reduced survivors have been able to maintain their existence only in those areas unfavorable to molluscan life where the competition is relatively slight.

The recent *Amauropsis* are typically boreal in distribution.

A. Maximum diameter is equal to two-thirds of the total altitude, maximum diameter of the body whorl near the median horizontal of the whorl .... *Amauropsis meekana*

B. Maximum diameter less than two-thirds of the total altitude, maximum diameter of the body whorl in front of the median horizontal. *Amauropsis compacta*

AMAUROPSIS MEEKANA Whitfield

Amauropsis paludinæformis Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 296. (Not *A. paludinæformis* Hall and Meek, 1855.)

Amauropsis meekana Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 131, pl. xvi, figs. 22-25.

Amauropsis meekana Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 21.

Amauropsis meekana Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 681, pl. lxxvii, figs. 1-3.

Description.—" Shell of medium size, elongate-subovate; spire moderately elevated, only about two-thirds as high above the aperture as the length of the aperture; volutions five or five and a half in the largest specimen; ventricose, with distinct, well marked sutures, which are very slightly channelled; body volution more distinctly ventricose than the others; axis solid; aperture ovate, acute at the upper end, rounded and slightly effuse below; outer lip thin and sharp; columella somewhat thickened by the deposit of the lip, and grooved below the margin of the deposit, but not umbilicate; surface of the shell marked by proportionately strong, transverse lines of growth, which are exceedingly irregular; and also by fine, even, corrugated spiral lines crossing them."—Whitfield, 1892.

Only a single imperfect cast apparently referable to this species was collected from the Matawan. It is a much larger shall than *A. compacta*, and relatively slender.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal, Delaware.

Collection.—Maryland Geological Survey.

AMAUROPSIS COMPACTA n. sp.

Plate XIII, Figs. 3, 4

Description.—Shell small, squat, relatively heavy; whorls five in number, increasing quite rapidly in size, narrowly tabulated, those of the spire subtrapezoidal in outline, the body evenly and quite strongly inflated; external surface smooth excepting for oblique incrementals; sutures deeply impressed; aperture holostomous, a little more than half the altitude of the entire shell, obliquely elliptical in outline; the outer lip a little more strongly arcuate than the inner and the anterior extremity a little more broadly rounded than the posterior; peristome continuous, the outer lip probably thickened, the inner lip reflected over the body wall and almost, but apparently not quite, closing the umbilicus; umbilical chink probably narrow but deep; columella reinforced in front of the umbilicus.

Dimensions.—Altitude 7.5 mm., maximum diameter 5.9 mm.

Type Locality.—McNeys Corners, Prince George's County.

The type, the only specimen in which the shell is preserved, is imperfect at the umbilicus so that it is impossible to tell some of the critical characters with assurance. The shell is rather heavy for *Amauropsis*, but in the totality of characters it seems to be closer to that genus than to *Euspira.* The form differs from *Amauropsis meekana* Whitfield in the squat outline and much more inflated body whorl.

Occurrence.—MONMOUTH FORMATION. ? Brightseat, Friendly, ? 2 miles southwest of Oxon Hill, Prince George's County.

Collection.—Maryland Geological Survey.

Family TROCHEIDAE

Genus MARGARITES Gray

[Ann. Mag. Nat. Hist., vol. xx, 1847, p. 271]

Shell thin, nacreous, trochiform or turbinate, whorls inflated, well rounded, as a rule, and usually few in number; external sculpture developed, dominantly spiral; suture lines impressed or channelled; aperture subcircular or obliquely produced; peristome not continuous; outer

Etymology: μαργαρίτης, a pearl.

lip thin, sharp and strongly arcuate, body wall heavily glazed; columella non-plicate; umbilicus profound, rarely closed by a reflected layer of callus; not margined by a crenulated umbilical keel.

Margarites is initiated apparently in the Upper Cretaceous and still maintains its minor position in the molluscan faunas. The genus is best represented to-day on the west coast of North America, where it has been subdivided by Dall into four sections, one of which is characteristically boreal, another temperate, the third warm-temperate and tropical, and the fourth abyssal in distribution.

A. Whorls three in number, spire relatively low........*Margarites depressa*
B. Whorls four in number, spire of moderate altitude....*Margarites abyssina*
C. Whorls five in number, spire relatively high, altitude and maximum diameter approximately equal.......................*Margarites elevata*

MARGARITES DEPRESSA n. sp.

Plate XIII, Fig. 6

Description.—Shell small, thin, nacreous, depressed, a little more than thrice coiled; whorls increasing regularly and rapidly in size, somewhat flattened behind, strongly rounded in front; external surface lineated with exceedingly fine, moniliform spirals restricted to a very thin external layer which is for the most part decorticated; aperture holostomous, circular in outline; body whorl rounding smoothly into the umbilical area; umbilical pit rather small but profound.

Dimensions.—Altitude 1.75 mm., maximum diameter 2.5 mm.

This species is conspicuous among the Maryland Upper Cretaceous representatives of the genus for its small size and depressed spire. The type is unique.

Occurrence.—MONMOUTH FORMATION.—Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

MARGARITES ABYSSINA (Gabb) Meek

Solarium abyssinus Gabb, 1861, Proc. Acad. Nat. Sci., Phila., for 1860, p. 94, pl. ii, fig. 9.

Margarita abyssinus Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 18.

Margarita abyssina Conrad, 1868, Cook's Geol. of New Jersey, p. 728.

Margarita abyssina Whitfield, 1892, Mon. U. S. Geol. Survey, vol. xviii, p. 133, pl. xvii, figs. 1-5.
Margarita abyssina Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 20.
Margarita abyssina Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 669, pl. lxxv, figs. 20-22.

Description.—"Shell conical; whorls three, rounded; mouth circular, surface markings unknown. A cast."—Gabb, 1861.

Type Locality.—Burlington County, New Jersey.

"Shell small, not exceeding half an inch in its greatest diameter; spire moderately elevated, the apical angle being about 70° or 75°; volutions four to four and a half, very ventricose, giving a circular section when broken across; suture deep and well marked, while the whorls in the internal cast are closely appressed and slightly imbedded into each other, showing the shell to be thin; also seen where the cast rests partially in the matrix, the space left by the removal of the shell where no compression has occurred being barely perceptible; umbilicus broad and open, showing several of the volutions within; surface marked by very fine, even, spiral lines over the entire shell, with an apparent stronger line on the periphery, and crossed by finer lines of growth, which are bent backward in crossing the volution, cancellating the surface."—Whitfield, 1892.

Margarites abyssina (Gabb) is intermediate in size and number of whorls and relative altitude of spire between *M. elevata* and *M. depressa*. It is, however, much closer to the former than to the latter.

Occurrence.—MATAWAN FORMATION. Ulmstead Point, Magothy River, Anne Arundel County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Woodbury clay, New Jersey. *Monmouth Formation.* Navesink marl, Tinton beds, New Jersey.

MARGARITES ELEVATA n. sp.

Plate XIII, Fig. 5

Description.—Shell of moderate size for the genus; whorls five in number, increasing regularly in size, flattened posteriorly in the casts,

strongly and evenly rounded medially and basally; shell not preserved but traces of a very fine and crowded spiral lineation still discernible on the cast near the aperture; aperture holostomous, subcircular in outline; body whorl rounding evenly into the rather large and very deep umbilical pit.

Dimensions.—Altitude 4.5 mm., maximum diameter 4.2 mm.

This species is separated from its close kin, *M. abyssina* (Gabb), by its more elevated spire and consequently smaller apical angle and the larger number of constituent whorls.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

CLASS SCAPHOPODA

Family DENTALIIDAE

Genus DENTALIUM Linné

[Systema Naturae, ed. x, 1758, p. 785]

Type.—*Dentalium elephanticum* Linné.

Shell solid, tubular, tusk-shaped, open at both ends; external surface smooth, longitudinally sulcate, or annulate; anterior orifice simple, not contracted.

"The researches of Sars have shown that the arched side of the shell is to be regarded as ventral and the concave side dorsal, but to avoid confusion in comparisons I have not corrected the terms in general use, which are the exact opposite of these. The posterior end of the shell in *Dentalium* may be circular or ovate and evenly truncate, oblique, undulated, fissured in the median line, or with slits, lateral or ventral, or both.

"The most usual form is that which is evenly transversely truncate; the next most common style is one in which there is a dorsal wave, or sulcus, or even a narrow slit of some length. The other combinations are less common. In a wide sense these variations depend upon the form of the mantle-edge or internal lining of the shell, which is an extremely

Etymology: A derivative of *dens*, a tooth.

contractile membrane capable of secreting shelly matter. This, like the shell, may be simply tubular, sulcate, etc., and when the shell is absolutely perfect the posterior end reflects the form of the membrane which secreted it, and which is known from observations on the recent shells to be capable of repairing damages to the calcareous tube which protects it. . . . .

"Another modification of the orifice has given rise to much misconception. Species with very thin shells usually live buried in soft mud which measurably protects them, but others with heavy shells appear to be more versatile; at all events, if the small end of the shell is accidentally broken off, the animal can repair it, and in species which have a simply tubular mantle and a thick shell the repairs take the shape of a small tube projecting from the blunt end of the large one, as it is impossible for the mantle to secrete a shell which is as large and thick as the original at the point of truncation. I have examined a great many recent *Dentalia,* and have never seen a specimen in which the 'tube-in-tube' was not obviously the result of the above process, and I believe it always to be so. . . . .

"Another form of repair is sometimes observed in species which normally have a dorsal wave or sulcus in the posterior orifice. Here not only will the broken tip be, as it were, double-lipped, but a slight absorption will take place in the middle line above, corresponding to the sulcus, even in the solid shell of the truncation. Such a state of affairs has been figured by Meyer (Bull. Ala. Geol. Survey, I, pl. i, fig. 2a, and pl. iii, fig. 2a) in specimens of *D. leai* and *D. danai* Meyer, but it is never what may properly be called normal, though occasionally it may have become habitual.

"Those who have studied large numbers of *Dentalia* will have been struck by the extreme sharpness and tenuity of the posterior portion of the young shell, which is almost invariably lost long before maturity has been reached, and will realize that only a carefully graded series connecting the very young with the adult will give anybody the means for describing the normal form of the posterior orifice with exactitude and accuracy.

"Still another pitfall is to be avoided in studying the characters of the posterior part of the shell. As has been stated, the posterior orifice often

has a dorsal slit, very narrow and prolonged in some cases. But it often happens that erosion, especially in specimens from deep water, modifies and sometimes simulates such slits, introducing them where normally they should not be, or lengthening them abnormally. There seems to be a peculiarity of some kind in the external prismatic layer of *Dentalium,* which lends itself to the propagation of erosion in longitudinal lines very much more effectively than at right angles to such lines. Hence we see specimens of a species, normally provided with a short slit, exhibiting an enormously long slit, or, starting at some little defect in the posterior margin, a narrow line of erosion, simulating a slit, may run a long distance up the shell. These abnormalities may usually be discriminated by comparison with numerous specimens of the same species. In cases where the student has only one or two specimens, he should refrain from putting reliance on characters which may be abnormal as a basis for describing new forms or for discriminating old ones.

"It may also be added that it rarely happens that smooth species do not show at least a little sculpture near the posterior end, or that sculptured ones do not show a modification of the sculpture toward the anterior end. Hence a broken fragment from either part of the shell can hardly be relied upon to give differential characters for the species as a whole. In the same species, among the sculptured ones a good deal of variation in the strength of the sculpture between different specimens is extremely common and should always be allowed for."—W. H. Dall, 1892.[1]

This genus is one of the most ancient of all the molluscan phylum. There is evidence of it early in the mid-Palæozoic, and in the late Mesozoic it was abundantly represented. The recent species number about one hundred and fifty. The larger forms are many of them abysmal. The animal lives, for the most part, buried head downward in the sand or mud, with the mantle spread to function as a gill, and the posterior end of the test extending obliquely upward into the clear water.

[1] Trans. Wagner Free Inst. Sci., Phila., vol. iii, pt. ii, pp. 436-438.

DENTALIUM PAUPERCULUM Meek and Hayden

Dentalium pauperculum **Meek and Hayden, 1861, Proc. Acad. Nat. Sci., Phila., for 1860, p. 178.**

Dentalium pauperculum **Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 17.**

Description.—" Shell small, arcuate, slender and tapering gradually; section circular; substance comparatively thick; surface smooth, but showing under a magnifier extremely fine, obscure lines of growth, which pass around somewhat obliquely. Length (of an incomplete specimen, measuring from the apex) 0.36 in., diameter of same at apex 0.03 in., diameter at large extremity 0.06 in. Location and position: Moreau River, Formation No. 5 of the Nebraska section."—Meek and Hayden, 1861.

Type Locality.—Moreau River, No. 5 of Nebraska section.

Meek later in 1876 reported the species from the Fort Pierre group as well as from the Fox Hills.

Fragments of a form which is apparently similar to that described by Meek and Hayden was collected in the Monmouth of Prince George's County. The material is so fragmentary that the determination is merely tentative. However, scaphopods as a group are rather deep water forms and for that reason less restricted in distribution than the shallow water types, so that there would be nothing remarkable in the occurrence of an identical species on the East Coast and in the Western Interior.

Meek, in his 1876 report, referred the species to *Eutalis,* but there does not seem to be sufficient evidence for a subgeneric determination in any of the available material.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Outside Distribution.—Pierre. Western Interior. *Fox Hills Sandstone.* Western Interior.

CLASS PELECYPODA

Order PRIONODESMACEA

A. *Taxodonta* Neumayr (Emend)

Superfamily NUCULACEA

Family NUCULIDAE Adams

Genus NUCULA Lamarck

[Prodr. Nouv. Class. Coq., vol. 1, 1799, p. 87]

Type.—*Arca nucleus* Linné.

Shell nacreous, small, trigonal to sub-circular or elliptical; umbones sub-central or posterior; two series of transverse, numerous and close-set hinge teeth, separated by a triangular chondrophore; surface generally smooth or concentrically striated; margins simple or crenulate; adductor impressions sub-equal, two in number; pallial line simple.

A. Adult shell exceeding 15 mm. in latitude; true sculpture not developed. *Nucula slackiana*

B. Adult shell not exceeding 15 mm. in latitude; concentric sculpture developed from the umbones to the basal margin.
   1. Concentric sculpture comparatively coarse; radial sculpture developed .... *Nucula amica*
   2. Concentric sculpture microscopically fine .... *Nucula microstriata*

NUCULA SLACKIANA Gabb

Plate XIX, Figs. 1-4

Leda slackiana Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 397, pl. lxviii, fig. 37 (erroneously cited as *36*).

Nuculana slackiana Meek, 1864, Check List Invert. Fossils N. A., Cret. and Jur., p. 8.

Nucula slackiana Cook. 1868. Geol. New Jersey, p. 725.

Nucula slackiana Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 318.

Nucula slackiana Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 103, pl. xi, figs. 2, 3.

Nucula slackiana Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 8.

Nucula percrassa Weller, 1907, Geol. Survey of New Jersey., Pal., vol. iv, p. 369, pl. xxix, figs. 1-5. (Synonymy and geographic distribution excluded.)

Not *Nucula percrassa* Conrad, 1858.

Description.—" Inequilateral (casts); muscular scars large and deep; margin crenate; cardinal line apparently curved, basal irregularly

Etymology: *Nucula*, a little nut.

rounded; hinge teeth apparently large, cup very distinct, pallial line very distinct.

"*Dimensions.*—Length about .6 in., width about .8 in.

"*Locality.*—Dark marl, Crosswicks, N. J. My collection.

"This is one of the finest casts I have ever seen from New Jersey. I take pleasure in dedicating it to my friend, Dr. J. H. Slack, to whom I am indebted for this and several other new species."—Gabb, 1860.

Gabb's type is now in the collection of the Philadelphia Academy of Natural Sciences.

Shell thick, heavy, nacreous, transversely ovate in outline; umbones prominent, inflated, inclined to be flattened upon their summits, feebly opisthogyrate, placed backward two-thirds to three-fourths of the total length; lunule and escutcheon ill-defined; posterior dorsal slope steeper than the anterior; anterior end broadly rounded or obscurely truncate; posterior end more sharply rounded; ventral margin approximately horizontal or gently arcuate in the medial portion; external surface finely striated radially and concentrically sculptured by the incrementals; particularly toward the ventral margin; hinge taxodont, the teeth, when perfact, arcuate, and very prominent, raised a couple of millimeters above the hinge plate, set in an anterior and a posterior series divergent at an angle of 120° or 125° beneath the umbones; anterior series numbering twenty to twenty-five, becoming increasingly fine toward the beaks; posterior series numbering ten or twelve, slightly less prominent toward the beaks; chondrophore narrow, spoon-shaped, directed forward from beneath the umbones; muscle scars deep, roughly semi-elliptical, placed at the distal ends of the hinge plate; pallial line simple, distinct; inner ventral margin finely crenate; immature forms relatively higher and less convex than the adults.

Nucula slackiana Gabb is abundant and readily recognizable. The shell substance is very thick and frequently weathers in such a way as to give an excellent cross section of the three layers which make up the shell—the outer radially sculptured with the component prisms normal to the surface, the inner, very thin, with the prisms laid parallel to the inner surface, the middle layer which makes up the bulk of the shell with the prisms laid

oblique to the surface. It has been confused in the synonomies and collections with *Nucula percrassa* Conrad of the South Atlantic and Gulf states. *Nucula percrassa* has been reported from New Jersey by a number of authors including Gabb, Meek, Whitfield, and Weller, but mostly in the form of casts. In Maryland, the shell itself is well preserved and abundant. The comparison of a large series from Maryland with a series from Owl Creek, 3 miles north of Ripley, Mississippi, Conrad's type locality, makes it probable that the forms are distinct. *Nucula slackiana* Gabb runs higher and heavier than the *Nucula percrassa* of Conrad; a typical individual from Maryland measures 33.8 mm. in length and 23 mm. in altitude, while one from Ripley measures 25.3 mm. in longitude, and 19.5 in altitude. The umbones are less prominent in the northern species, less convex, and more feebly opisthogyrate, the lunule and escutcheon less sharply differentiated and the ventral margin less flattened. There is a strong tendency in the *N. percrassa* toward a slight contraction of the ventral margin toward the posterior margin, thus giving to the rear end of the shell a nasute aspect which is absent in *N. slackiana.* The angle of divergence between the anterior and posterior series of hinge teeth is higher in Conrad's species, the muscle scars are usually deeper and the crenulations upon the inner ventral margin finer, sharper, and farther produced into the interior of the valve.

The northern race is much more uniform in its characters, however, than the southern. Conrad's type is rather extreme. Many of the individuals from the Ripley are very much higher, relatively, and though they do not quite bridge the gap between *N. percrassa* and *N. slackiana,* they materially diminish it. There is, however, a peculiar characteristic flattening of the umbones and of the ventral margin of the Gulf forms which is, apparently, not reproduced in any of the northern specimens.

Occurrence.—MATAWAN FORMATION. Summit Bridge, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Two miles west of Delaware City on John Higgins farm, Delaware. Brightseat, railroad cut west of Seat Pleasant, Brooks estate near Seat Pleasant, Friendly, 1 mile west of Friendly, and McNeys Corners, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey.

Outside Distribution.—*Nucula slackiana* Gabb. *Magothy Formation.* Cliffwood clay, New Jersey. *Matawan Formation.* Merchantville clay marl, Marshalltown clay marl and Wenonah sand, New Jersey.

NUCULA AMICA n. sp.

Plate XIX, Figs. 5, 6

Description.—Shell nacreous, small, moderately heavy, transversely ovate-trigonal in outline, umbones small, feebly inflated, inconspicuous, opisthogyrate, slightly posterior in position, lunule elongated, defined by the angulation of the valve and by the partial evanescence of the external sculpture; escutcheon large, cordate and appressed, defined by the abrupt evanescence of the disk sculpture, smooth excepting for a couple of sulcations subparallel to the dorsal margin; anterior end more produced than the posterior, obscurely angulated at the ventral margin, posterior end obliquely truncated, base line feebly arcuate; external surface sculptured with approximately forty concentric ridges uniform in size and spacing, obtuse and asymmetrical; their dorsal slope steeper than their ventral; entire exterior exclusive of the lunule and escutcheon overridden by very faint, microscopically fine radial lirations separated by interspaces of equal width; ligament internal, lodged in a chondrophore which extends obliquely forward from beneath the umbones; teeth very fine, even and close-set, slightly V-shaped; characters of adductors and pallial line lost; inner basal margin finely crenate.

Dimensions.—Altitude 6 mm.; latitude 8 mm.; semi-diameter 2.3 mm.

Type Locality.—One mile west of Friendly, Prince George's County.

Nucula amica is described from very much battered valves, but the sculpture is so unique that it justifies the introduction of the form into the literature.

Occurrence.—MONMOUTH FORMATION. Brightseat, 1 mile west of Friendly, Prince George's County.

Collection.—Maryland Geological Survey.

NUCULA MICROSTRIATA n. sp.

Plate XIX, Fig. 7

Description.—Shell small, very thin and fragile, ovate in outline, moderately inflated in the umbonal region, compressed toward the margins; umbones rather inconspicuous, their apices acute, opisthogyrate, slightly posterior in position; lunule much produced, ill-defined by reason of the flattening of the valves; escutcheon quite deeply impressed, elongate-cordate in outline; dorsal margins oblique, diverging from the apex at an angle of about 100°; posterior dorsal slope steeper than the anterior; anterior extremity broadly rounded, merging more gradually into the dorsal margin than into the ventral; posterior dorsal margin apparently produced until it joins the upcurved base line; ventral margin very broadly arcuate; entire external surface sculptured with microscopically fine and crowded concentric striæ; hinge characters somewhat obscured; teeth, short serrate, arranged in two discrete series separated by an oblique chondrophore; anterior series numbering about twenty, the posterior less than half as many; characters of adductor scars and pallial line not known.

Dimensions.—Altitude 6 mm.; latitude 8 mm.; semi-diameter 2.5 mm.

This species is well characterized by the small size, thin shell and very finely and closely striated external surface.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Family LEDIDAE

Genus LEDA Schumacher

[Essai, 1817, pp. 55, 172]

Type.—*Leda rostrata* Gmelin.

Shell solid, porcellaneous, transversely elongate, rounded anteriorly, more or less rostrate posteriorly; beaks proximate, often tumid, feebly opisthogyrate; exterior surface concentrically sculptured; hinge armature

Etymology: ***Leda*, the mother of Castor and Pollux.**

taxodont, the teeth arranged in an anterior and a posterior series; chondrophore subumbonal, trigonal; pallial line interrupted by a shallow sinus, due to the short siphons of the animal; inner ventral margins simple.

This genus also originated in the Paleozoic, but in the Silurian, one period later than did *Nucula*. The eighty odd living species have a wide geographic and bathmetric distribution, although the majority are boreal.

A. Latitude of adult shell not exceeding 8 mm; outline trigonal, rostrum obliquely produced, obtusely angulated..................*Leda whitfieldi*
B. Latitude of adult shell exceeding 10 mm, outline transversely elongated, rostrum squarely truncate........................*Leda rostratruncata*

LEDA WHITFIELDI n. sp.

Plate XIX, Figs. 10-12

Nuculana pinnaformis Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 108, pl. xi, fig. 8. (Synonomy and fig. 7 excluded.) (Not *Leda pinnaformis* Gabb, 1860.)

Description.—Shell small, convex, cuneate dorsally, arcuate ventrally, forming roughly a sector of 120°; posterior end more produced than the anterior and sharply rostrate; anterior end evenly rounded; umbones inflated, flattened upon their summits; incurved, proximate; external adult sculpture of twenty to thirty concentric rugæ, strongest and most crowded toward the ventral margin, altogether absent upon the umbones and evanescent in the slightly depressed area directly in front of the rostrum; teeth fine but sharp, becoming increasingly finer and convergent beneath the umbones; both anterior and posterior series numbering from thirteen to seventeen; ligament pit trigonal, minute, subumbonal; muscle scars small, placed at the distal ends of the hinge; pallial line running close to the ventral margin; pallial sinus short, steeply ascending, squarely truncate.

Dimensions.—Altitude 3.7 mm.; latitude 6.5 mm.

Type Locality.—Haddonfield, New Jersey.

Forms referable to *Leda whitfieldi* were included by Whitfield under *Leda pinnaformis* Gabb, an error perpetuated by Weller and others. The

differences are sufficiently obvious in Whitfield's two figures. Gabb's species is much higher relatively, with higher, more prominent umbones, a broader posterior keel, and a finer concentric sculpture. *Leda whitfieldi* is quite common in the Monmouth of Prince George's County, Maryland.

The form figured by Whitfield from Haddonfield, New Jersey, which must serve as the type, is in the collection of the Philadelphia Academy of Natural Sciences.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, Friendly, 1 mile west of Friendly, McNeys Corners, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Matawan Formation.* Woodbury clay, New Jersey.

LEDA ROSTRATRUNCATA n. sp.

Plate XIX, Figs. 8, 9

Description.—Shell very thin and fragile, transversely elongated, moderately convex, umbones small, not very prominent, incurved and opisthogyrate, placed a little in front of the median horizontal; anterior end a little shorter than the posterior, broadly rounded distally; posterior end strongly rostrate, the rostrum squarely truncated, and isolated by a broad and shallow depression in front of it; lunule narrow but well defined; escutcheon strongly differentiated, outlined by a low ridge, persistent to the extremity of the keel; external surface sculptured with thirty to forty fine, concentric rugæ, regular in size and spacing over the entire disk but absent upon the tips of the umbones and the lunule and escutcheon; teeth arranged in two discrete series, becoming finer toward their point of convergence beneath the umbones; anterior series numbering approximately twenty-five denticles, the posterior twenty-eight; pallial line and muscle scars obscure.

Dimensions.—Right valves, longitude 18.5 mm., 8.5 mm.; left valve of another individual, longitude 14.5 mm., altitude 7 mm.

The species may be properly referable to *Yoldia*, but the prominence of the rostral ray and the well differentiated lunule and escutcheon are much more suggestive of *Leda*. It is quite probable, too, that *Leda rostratruncata* may be identical with some of the numerous casts described from the New Jersey Cretaceous, but none of them exhibit the squarely truncated posterior keel set off by the contraction of the base line in front of it, a character which is so conspicuous in *Leda rostratruncata*. The form is the most abundant representative of the genus in the Monmouth of Prince George's County.

Occurrence.—MONMOUTH FORMATION. Brightseat, railroad cut west of Seat Pleasant, Brooks estate near Seat Pleasant, Friendly, 1 mile west of Friendly, 2 miles south of Oxon Hill, Fort Washington, Prince George's County.

Collection.—Maryland Geological Survey.

Genus YOLDIA Moeller

[Index Moll. Groenl., 1842, p. 18]

Type.—*Yoldia arctica* Gray.

The genus differs from *Leda* mainly in the posterior gape of the valves and the much deeper pallial sinus, resulting from the longer siphons.

A. Posterior dorsal margin approximately horizontal, and sub-parallel to the straight.base line............................*Yoldia longifrons*
B. Posterior dorsal margin excated or oblique, base line more or less arcuate.
- **1. Posterior dorsal margain excavated, umbones compressed. *Yoldia gabbana***
- **2. Posterior dorsal margin oblique, umbones moderately inflated. *Yoldia noxontownensis***

YOLDIA LONGIFRONS (Conrad) Johnson

Plate XIX, Fig. 13

***Leda longifrons* Conrad, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 281, pl. xlvi, fig. 18.**

***Nuculana longifrons* Meek, 1864, Check List Inv. Foss. N. A., Cret. and Jur., p. 8.**

·*Nuculana longifrons* Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 107, pl. xi, figs. 16, 17.

Etymology: Dedicated to the Count of Yoldi.

Yoldia longifrons Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 8.
Yoldia longifrons Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 381, pl. xxx, fig. 5.

Description.—" Oblong, slightly ventricose, very inequilateral; hinge and basal margins parallel; anterior end acutely rounded, posterior obtusely rounded; cardinal teeth minute and very numerous."—Conrad, 1860.

Type Locality.—Eufaula, Alabama.

" Shell of moderate size, transversely subelliptical or subovate in form, a little narrower behind than in front of the beaks. Beaks very small and inconspicuous, situated rather more than one-third of the entire length from the anterior end of the valve. Cardinal margin very gently declining on each side of the beaks; anterior end rounded, longest above the middle of the height; posterior end more narrowly rounded, longest just below the extremity of the hinge; basal line very gently curved in the middle and more abruptly so toward the extremities. Surface of the shell polished, but marked by extremely fine concentric striæ of growth. In the interior the hinge-line is marked by proportionally long curved teeth; those on the anterior side being largest and numbering fifteen or twenty, those of the posterior side very small and numerous."—Whitfield, 1885.

A single imperfect valve found in a nodule near Summit Bridge on the Chesapeake and Delaware Canal has been referred to this species.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Woodbury clay, New Jersey. *Eutaw Formation* (Tombigbee sand). *Exogyra ponderosa* zone, *Mortoniceras* subzone, of Georgia and Alabama. *Ripley Formation. Exogyra ponderosa* zone, Union Springs, Alabama. *Exogyra costata* zone, Eufaula, Alabama, and northern Mississippi. *Selma Chalk. Exogyra costata* zone of east-central Mississippi.

YOLDIA GABBANA (Whitfield)

Leda protexta Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 397, pl. lxviii, fig. 36. (Not *L. protexta* Gabb, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 303, pl. xlviii, fig. 23.)

Nuculana gabbana Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 106, pl. xi, figs. 11-13.

Leda gabbana Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 378, pl. xxix, figs. 28-30.

Description.—" Shell of moderate size, extremely elongated, the length being nearly twice and a half the extreme height. Valves convex, regularly and evenly rounded. Beaks small, appressed and incurved, and distinctly inclined toward the narrower end of the shell, scarcely rising above the hinge line on the wider part, and situated about two-fifths of the length from the larger end. Cardinal margin on the wider end gently arcuate and a little more strongly concave on the narrower side of the beak; large extremity of the shell sharply rounded; basal margin gently rounded throughout and the posterior end narrow and rounded. As the specimen is an internal cast, it preserves no evidence of the surface characters. The muscular scars are extremely faint and the pallial line undistinguishable, although the cast is in an excellent state of preservation and somewhat polished on the surface from the perfect condition. The hinge-line has been marked by a large number of very fine teeth, gradually increasing in size from the center outward. On the wider end of the shell there are about twenty-five visible under a glass and about twenty somewhat stronger ones on the narrower side of the beak. The ligamental pit has been of moderate size, but well marked and deep."—Whitfield, 1885.

Type Locality.—Hardeman County, Tennessee.

Casts occurring in the Matawan, near the mouth of the Magothy River, have been referred to this species. They seem a little higher and less smoothly rounded than Whitfield's *gabbana,* but agree very well in size and general contour. Although the characters of the pallial sinus have not been detected, the large size and the produced posterior end suggest *Yoldia* rather than *Leda.*

Occurrence.—MATAWAN FORMATION. Ulmstead Point, Anne Arundel County.

Collection.—Maryland Geological Survey.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey. *Ripley Formation.* Hardeman County, Tennessee.

YOLDIA NOXONTOWNENSIS n. sp.

Plate XIX, Fig. 14

Description.—Shell approximately equivalved, inequilateral, elongate, transversely ovate in outline, moderately inflated in the umbonal region, flattening distally and toward the base; umbones rather tumid, opisthogyrate, slightly anterior in position; umbonal angle 145° to 150°, anterior dorsal slope higher than the posterior, anterior lateral margin rounding evenly into the base; shell produced posteriorly, obscurely rostrate and distally truncate; base line asymmetrically arcuate, obliquely ascending behind; external sculpture not known; hinge taxodont, teeth V-shaped, acutely angulated, closely crowded, arranged in two discrete series, probably about twelve in the anterior and fifteen in the posterior series; muscle impressions and sinus not observed.

Dimensions.—Altitude 8 mm.; latitude 18 mm.; semi-diameter 3 mm.

The species is allied apparently to *Y. protexta* (Conrad), but is more inflated in the umbonal region and relatively higher and less produced both anteriorly and posteriorly. It is only after long hesitation that a species founded on material so imperfect is given a place in the nomenclature.

The greensand at Noxontown Pond has yielded a most baffling fauna. The fossils are exceedingly prolific, but so ill-preserved that even good casts can be obtained only with the greatest difficulty. The horizon is higher than any in Maryland and is possibly synchronous with the Rancocas of New Jersey, although there are a number of peculiar forms at both localities. It seems most unfortunate that such a fauna must be either disregarded or inadequately introduced.

Occurrence.—RANCOCAS FORMATION. South feeder Noxontown Pond, Delaware.

Collection.—Maryland Geological Survey.

Genus PERISSONOTA Conrad

[Am. Jour. Conch., 1869, vol. v, p. 98]

Type.—Perissonota protexta Conrad.

" Equivalved, elongated; posterior hinge line long, curved, linear, with numerous close, transverse teeth, extending nearly to the end margin; anterior hinge area broad, oblique and somewhat distant from the hinge margin. No fosset under the apex?"—Conrad, 1869.

The characters which isolate the group are the anterior umbones, the marked posterior extension of the shell, and the persistence of the posterior dental series almost to the extremity of the dorsal margin. The pallial sinus is unknown, but it is quite probable that the species referred to this group will find their proper station as a subgenus under *Yoldia.*

A. Posterior dorsal margin not approximately parallel to the base line, external surface regularly striated concentrically...*Perissonota protexta*
B. Posterior dorsal margin approximately parallel to the base line; external surface not regularly striated concentrically.......*Perissonota littlii*

PERISSONATA PROTEXTA Conrad

***Perrisonota protexta* Conrad, 1869, Am. Jour. Conch., vol. v, p. 98, pl. ix, fig. 24.**

***Perrisonota protexta* Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 110, pl. xi, figs. 14, 15.**

***Leda protexta* Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 8.**

***Perrisonota protexta* Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 379, pl. xxx, figs. 1, 2.**

Description.—" Subensiform, smooth, convex; anterior side short, extremity situated nearer the hinge than ventral margin."—Conrad, 1869.

Type Locality.—Haddonfield, New Jersey.

" Shell small, ensiform, extremely elongated posteriorly, and gradually narrowed from the beaks. Valves depressed convex with very small inconspicuous beaks, which curved backward, and with an obsolete carination extending from them backward to the postero-basal angle. Anterior end broadest, sharply rounded; posterior end narrowly rounded, longest above the middle. Hinge line arched upward in front of the beaks, and gently concave posteriorly throughout the entire length of the shell. Basal line

Etymology: *Perissonota*, from περισσός, beyond, and νῶτος, back; an allusion to the abnormal extension of the teeth along the dorsal region.

moderately curved, more prominent just in advance of the beaks. Surface of the shell polished or marked by very fine concentric lines of growth, except on the posterior cardinal slope, where they unite and form a few inconspicuous folds. The interior of the shell shows the hinge-line to be marked by several small transverse teeth on the anterior side, and on the posterior side they extend almost to the hinge extremity."—Whitfield, 1885.

P. protexta is represented in Maryland only by incomplete individuals which contribute nothing to the knowledge of the characters of the species.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, Woodbury clay and Wenonah sand, New Jersey. *Monmouth Formation.* Tinton beds, New Jersey. *Eutaw Formation* (Tombigbee sand). *Exogyra ponderosa* zone, *Mortoniceras* subzone of Georgia. *Ripley Formation. Exogyra costata* zone, Houston, Mississippi; *extreme top of zone,* Georgia. *Selma Formation. Exogyra costata* zone, east-central Mississippi.

PERISSONATA LITTLII n. sp.

Plate XX, Figs. 1, 2

Description.—Shell compressed almost to a single plane, transversely elliptical in outline; umbones within the anterior fourth, indicated merely by the focusing of the faint concentric striations, scarcely breaking the contour of the dorsal margin and the faint lateral curvature; anterior and posterior dorsal margins converging at an angle of 165° or 170°; posterior dorsal margin broadly and gently constricted behind the umbones, approximately horizontal in general direction; anterior dorsal margin sloping away from the horizontal at an angle of not far from 5°; anterior lateral margin rounding broadly and smoothly into the base line; posterior lateral margin broken, but the growth lines indicate an obscure truncation; base line broadly arcuate, merging much more gradually into

the anterior lateral margin than into the posterior; area so clearly defined in most of the *Ledidæ* indicated more by a change in the direction of the growth lines than in the plane of the shell; external surface faintly striated with irregular incrementals least faint upon the anterior portion; hinge taxodont but nothing further known about the characters of the interior.

Dimensions.—Altitude 10.3 mm.; latitude 28 ± mm.; diameter of double valves 2.9 mm.; distance from umbones to anterior margin 6.5 mm.

This species is well characterized by the elliptical outline, the subparallel posterior dorsal margin and base line, and the irregularity of the faint incremental striæ. *Perissonota protexta* Conrad is alate rather than elliptical, and the incremental sculpture is sharp and regular. The species is described from double valves from which a small piece of shell substance has been chipped away at the hinge line revealing the taxodont dentition.

This species is named for Dr. Homer P. Little, formerly with the Maryland Geological Survey and now at Colby College.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

Superfamily ARCACEA
Family PARALLELODONTIDAE
Genus NEMODON Conrad

[Am. Jour. Conch., vol. v, 1869, p. 97]

Type.—" *Nemodon eufalensis* " Conrad = *Nemodon conradi* Johnson. Not *Arca* (*Macrodon*) *eufalensis* Gabb, 1860.

" Equivalved, thin; hinge line long and straight, or slightly curved under the umbo; hinge in left valve with three linear teeth parallel with the anterior cardinal margin; posterior lateral tooth double, very long, linear; under the apex a few granular teeth."—Conrad, 1869.

Etymology: *Nemodon*, from νῆμα, thread, and ὀδούς, tooth.

The form described and figured by Conrad is not that described by Gabb under the name of *Arca* (*Macrodon*) *eufalensis,* but a distinct species. Charles W. Johnson,[1] while listing the Cretaceous types in the collection of the Philadelphia Academy of Natural Sciences, discovered the error, and gave to Conrad's shell the name of *Nemodon conradi.*

Nemodon is separated from *Arca* by the development of both horizontal and vertical teeth and from *Cucullæa* by the greater relative length of the horizontal laminæ. The genus is apparently confined to the Cretaceous.

A. Shell thin; inner ventral margins simple.
  1. Base line parallel to dorsal margin .... *Nemodon eufalensis*
  2. Base line not parallel to the dorsal margin .... *Nemodon stantoni*
B. Shell heavy; inner ventral margins crenate .... *Nemodon cecilius*

NEMODON EUFALENSIS (Gabb) Whitfield

Plate XX, Figs. 3, 4

Arca (Macrodon) eufalensis Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 398, pl. lxviii, fig. 39 (incorrectly cited as *38*).

Nemodon eufaulensis Whitfeld, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 83, pl. xii, figs. 3, 4. (Synonomy and fig. 5 excluded.)

Nemodon eufaulensis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., vol. lvii, p. 9.

Nemodon eufaulensis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 385, pl. xxx, figs. (?) 8-11 (casts only).

Description.—" Inequilateral; beaks large; umbones large and slightly grooved in the middle by a shallow sulcus, which extends nearly to the base of the shell; area very small; hinge line straight, lower edge of the hinge slightly curved; lateral teeth very long; anterior margin curved, basal sinuous, posterior margin curved, upper part inclined anteriorly; surface marked by numerous radiating ribs and smaller transverse lines.

" *Dimensions.*—Length .4 in.; width .5 in.

" *Locality.*—Eufala, Alabama. Ripley Group. My collection."—Gabb, 1860.

Shell transversely elliptical to subrhomboidal in outline, flexuous medially, moderately inflated in the umbonal region, flattening toward the ventral margin; umbones broad, subangular, medially depressed, low,

[1] Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 9.

moderately prominent, feebly prosogyrate, slightly anterior in position; ligament area very small, and almost entirely in front of the umbones; hinge and ventral margins parallel; anterior lateral margin angulated dorsally, broadly rounded at the base; posterior lateral margin obliquely truncate; external sculpture of very fine, flattened, radial threadlets, forty to fifty in number, least fine and most flattened laterally particularly upon the posterior slope; interradials linear; concentric sculpture manifest in minute corrugations of the radials particularly upon the disk; hinge teeth laminar, parallel or subparallel to the hinge line; anterior teeth parallel to the hinge, rather short, that nearest the hinge margin a little longer than the two beneath it; posterior teeth also three in number, discrepant in size and slightly oblique to the hinge; medial lamina the longest, produced beyond the distal extremity of the cardinal line; the one dorsal to it merely the locally elevated margin of the hinge plate, that ventral to it also produced beyond the cardinal margin but not more than half the length of the medial lamina, disappearing within the umbonal cavity; characters of cicatrices and pallial line obscure.

Gabb's type is in the collection of the Philadelphia Academy of Natural Sciences.

Johnson (see synonymy) was the first to call attention to the fact that the form described and figured by Conrad[1] was not the *Arca* (*Macrodon*) *eufalensis* of Gabb, but a distinct species to which he suggested that the name *Nemodon conradi* be assigned.

This *Nemodon conradi* is separated from the true *N. eufalensis* by the less elongated outline, the more nearly central umbones and by the presence of a fine radial sculpture over the entire external surface, the radials least elevated on the medial portion.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, and McNeys Corners, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum.

[1] Conrad, 1869, Amer. Jour. Conch., vol. v, p. 97, pl. ix, fig. 16.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl and Marshalltown clay marl of New Jersey. *Monmouth Formation.* Navesink marl and Tinton beds of New Jersey. *Ripley Formation. Exogyra costata* zone, Georgia; Eufaula, Alabama; northern Mississippi. *Extreme top of zone,* Pataula Creek, Georgia, and Chattahoochee River, Alabama.

NEMODON STANTONI n. sp.

Plate XIX, Fig. 15

Description.—Shell transversely elongated, rudely trapezoidal in outline, the posterior basal margin obliquely produced; dorsal margin horizontal, more than two-thirds the entire length of the shell; anterior lateral margin obliquely truncated dorsally and meeting the hinge at an angle of 50° or 55°, broadly and smoothly rounded ventrally; posterior lateral margin also obliquely truncated, meeting the dorsal margin at an angle of approximately 65°, produced ventrally and rounding rather sharply into the base; ventral margin more sharply upcurved behind than in front, straight medially but not parallel with the dorsal margin; umbones small, acute, proximate, placed a little in front of the median line; umbonal ridge acute in the umbonal region but becoming broader and more obtuse away from the umbones and obsolete near the margin; external surface sculptured with a microscopically fine radial lineation, least feeble anteriorly and over the umbonal ridge; hinge imperfect in the umbonal region of the unique type; distal teeth laminar, elongated parallel to the hinge margin, apparently two on each side, the dorsal tooth the more produced in the anterior series, the ventral the more produced in the posterior; characters of interior not known.

Dimensions.—Altitude, 16.5 mm.; latitude 33.5 mm.; semi-diameter 4.5 mm.

This species is named for Dr. Timothy W. Stanton, Chief Paleontologist of the U. S. Geological Survey.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collection.—Maryland Geological Survey.

NEMODON CECILIUS n. sp.

Plate XX, Figs. 5-7

Description.—Shell large for the genus, transversely elongated, inflated, umbones rather high and prominent, not widely separated, the apices acute and turned a little forward, slightly anterior in position; hinge line elongated, horizontal; anterior lateral margin squarely truncate, joining the cardinal margin at an angle of approximately 90°, posterior lateral truncation slightly oblique; base line arcuate, broadly upcurved anteriorly, more produced and sharply rounded posteriorly; shell obtusely carinate from the umbones to the posterior basal angle; external surface probably sculptured with fine radial liræ separated by linear sulci which tend to arrange themselves in pairs; radial sculpture occasionally interrupted by a prominent growth line, especially toward the ventral margin; hinge armature of two or three anterior and three or four posterior teeth, elongated, transversely striate and parallel to the hinge margin, the more ventral teeth shorter than those behind them and very slightly oblique; between the two series a few minute cardinal denticles transverse to the hinge; character of muscle scars unknown excepting for a faint linear depression extending midway along the posterior area from the umbones to the lateral margin implying a low buttress in front of the posterior adductor; inner basal margins coarsely crenate.

Dimensions.—Altitude 23 mm.; latitude 29.5 mm.; semi-diameter 18.5 mm.

This puzzling form is known only by numerous casts of the interior from the type locality, and by a cast of the exterior which is probably, though by no means certainly, referable to the same species. The generic affinities are rather dubious; the general outline, dentition and character of the sculpture (if the cast of the exterior has been correctly united with those of the interior) are those of *Nemodon,* but it is rather large for that genus. It is possible that the presence of a posterior buttress scar, a character which strongly suggests *Cucullæa,* is merely concomitant with the heavier shell and is of no great systematic value. The crenulation of the inner ventral margins is unknown in *Cucullæa,* but occurs occasionally in

the heavier *Nemodon*. The unusual combination of the *Nemodon* dentition, the posterior buttress and the crenate margins seem to justify the description of forms which would otherwise not be noted in the literature.

The species is quite abundant at the type locality.

Occurrence.—MONMOUTH FORMATION. Fredericktown, Cecil County.

Collection.—Maryland Geological Survey.

Genus CUCULLAEA Lamarck

[Syst. An. sans Vert., 1801, p. 116]

Type.—*Arca concamerata* Martini = *Cucullæa auriculifera* Lamarck.

Shell large, heavy, inflated, rhomboidal or cordiform, equivalve or subequivalve; umbones prominent, incurved, separated by a rather wide cardinal area sculptured with divergent ligamentary grooves; external sculpture dominantly radial; hinge taxodont; medial teeth transverse or slightly oblique to the hinge margin; distal teeth sub-parallel to it; posterior adductor supported by a radial buttress; inner ventral margins crenate.

Cucullæa is one of the most conspicuous genera in the bivalve faunas of the Mesozoic, particularly toward the close of the epoch. Though much reduced in species it is still abundantly represented by individuals in many of the Eocene faunas. Only three species survive to the present day, all of them denizens of the Indian Ocean or China Sea.

A. Shell very heavy, altitude of adult exceeding 35 mm.; casts obliquely produced posteriorly.................................*Cucullæa vulgaris*
B. Shell not very heavy, altitude of adult shell rarely exceeding 35 mm.; shell and casts rudely rectangular in outline......*Cucullæa carolinensis*
C. Shell very heavy, altitude of adult shell exceeding 35 mm.; shell and casts conspicuously globose...........................*Cucullæa antrosa*

CUCULLÆA VULGARIS Morton

Plate XX, Figs. 8, 9; Plate XXI, Figs. 1, 2

Cucullæa vulgaris Morton, 1830, Am. Jour. Sci., 1st ser, vol. xvii, p. 285; vol. xviii, pl. iii, fig. 21.

Cucullæa vulgaris Morton, 1830, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 199.

Etymology: *Cucullus*, hood; the outline of the high, incurved umbones is somewhat suggestive of a monk's hood.

Cucullæa vulgaris Morton, 1834, Synop. Org. Rem. Cret. Group, U. S., p. 64, pl. iii, fig. 8; pl. xiii, fig. 5.
Cucullæa capax Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser., vol iii, p. 328, pl. xxxv, fig. 2.
Cucullæa tippana Conrad, 1858, _Ibidem_, p. 328.
Cucullæa vulgaris Gabb, 1862, Proc. Acad. Nat. Sci., Phila for 1861, p. 326.
Cucullæa vulgaris Meek, 1864, Check List Invert. Fossils N. A., Cret. and Jur., p. 8.
Cucullæa tippana Meek, 1864, _Ibidem_.
Idonearca vulgaris Cook, 1868, Geol. of New Jersey, p. 376, text figure.
Idonearca vulgaris Conrad, 1868, _Ibidem_, p. 725.
Idonearca vulgaris Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 313.
Idonearca tippana Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 95, pl. xii, figs. 19-21.
Idonearca vulgaris Whitfield, 1885, _Ibidem_, p. 98, pl. xiii, figs. 1-5.
Idonearca medians Whitfield, 1885, _Ibidem_, p. 199, pl. xxvi, figs. 5, 6.
Cucullæa vulgaris Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 8.
Cucullæa tippana Johnson, 1905, _Ibidem_.
Cucullæa vulgaris Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 397, pl. xxxii, figs. 5, 6.
Cucullæa tippana Weller, 1907, _Ibidem_, p. 394, pl. xxxi, figs. 5-10; pl. xxxii, figs. 1, 2.

Description.—" Ventricose, triangular, flattened before; beak prominent and incurved; shell thick, with numerous delicate longitudinal striæ.

" Length an inch and a quarter; breadth an inch and three-fourths."—Morton, 1830.

Type Locality.—Chesapeake and Delaware Canal, Delaware.

Shell very thick and heavy, moderately large, evenly inflated, the young sub-quadrate in outline, the adults obliquely produced along the posterior keel; anterior margin squarely truncate dorsally, merging ventrally with a broad and gentle curve into the basal margin, which is approximately horizontal in the young, but becomes increasingly oblique as the form matures; posterior lateral margin squarely truncate in the young forms, obliquely truncate in the adults; umbones very prominent, distant, orthogyrate, their summits somewhat flattened; external surface sculptured with exceedingly fine radial liræ, crowded but rather irregular in spacing, tending, however, to be arranged in pairs, often less feeble upon the posterior keel, though more distant and occasionally obsolete upon the flattened posterior area; radial sculpture relatively strong in the umbonal

region, where it lends a somewhat punctate aspect to the shell by cutting up the grooves between the incrementals into a series of minute pits; concentric sculpture incremental in character but over-riding the radial, resting stages crowded and conspicuous toward the ventral margin; cardinal area high rhomboidal, sulcated with concentric diamond-shaped ligament grooves which vary in number with the age of the individual but may be as many as nine in the adult; hinge line straight, from a little less than one-half to more than two-thirds the total latitude; ventral margin of the hinge plate gently arcuate, dentition vigorous, the medial teeth discrete, the distal teeth hook-shaped, the number of vertical teeth larger both absolutely and relatively in the adult form; muscle scars very prominent, the anterior high up under the hinge plate, the posterior buttressed by a prominent radial groove; pallial line simple, rather near the base; inner margins not crenulated.

The casts of *C. vulgaris* Morton, the form in which the species most commonly occurs along the middle Atlantic slope, are conspicuous for the high, compressed umbones and the obliquely produced posterior keel. The groove is very deep but is not greatly produced dorsally. The great thickness of *Cucullæa* shell, particularly in the medial portion, leaves a relatively small cavity, thus giving a surprisingly compressed cast.

C. capax, described by Conrad from the Ripley of Mississippi, is probably identical with *C. vulgaris,* though it may be consistently more inflated. The fact that the northern form is represented most frequently by casts and the southern by the original shell makes it difficult to determine their exact relationship.

Occurrence.—MATAWAN FORMATION. Camp Fox, Chesapeake and Delaware Canal: Post 198, Chesapeake and Delaware Canal; Camp U & I, Chesapeake and Delaware Canal; Post 157, Chesapeake and Delaware Canal, Delaware; north shore Round Bay, Severn River, Anne Arundel County, Maryland. MONMOUTH FORMATION. John Higgins farm, 2 miles west of Delaware City, Bohemia Mills, Cayots Corner, right bank of Bohemia Creek near Scotchman's Creek, Cecil County; Brightseat, Brooks estate near Seat Pleasant, Fort Washington, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey. *Ripley Formation.* *Exogyra costata* zone, Eufala, Alabama; Pontotoc, Union and Tippah counties, Mississippi; Lexington, Tennessee. *Selma Chalk formation.* *Exogyra costata* zone, Wilcox County, and along the Tombigbee River, Alabama; east-central Mississippi.

CUCULLÆA CAROLINENSIS (Gabb)

Idonearca carolinensis **Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 314.**
Idonearca carolinensis **Boyle, 1893, Bull. U. S. Geol. Survey, No. 102, p. 152.**

Description.—" Shell subquadrate, convex, hinge line just one-half the length of the shell; beaks small, incurved, umbones prominent and rounded; posterior slope nearly vertical; anterior end regularly rounded, retreating obliquely below; base broadly convex, most prominent in the middle. Surface in the adult marked only by irregular lines of growth; in the young crossed by very numerous and very fine radiating lines; hinge small. In the adult the middle (transverse) teeth show a tendency to irregularity, and even partial obliteration. Lateral teeth perfectly parallel with the hinge line; area small. Internal plate thin and elevated. Length 2 in.; width 1.5 in.; depth of single valves .75 in. This species grows about the size of *I. vulgaris,* but is less oblique, with rounder outlines and a more central beak. The area is smaller, and the whole shell is more quadrate. The markings of the young shell are as minute as those of *Trigonarca saffordi* Gabb, but of a different character, and the present species is proportionally shorter, more oblique, and more convex than that. *I. capax* Conrad is a heavy shell, remarkably thick, and will, I think, prove to be identical with *vulgaris.* I referred it to *antrosa* by mistake in the *Synopsis of Cret. Mollusca* for that species. From *I. neglecta* this species can be at once distinguished by the more convex valves and by the umbonal angle. From the Ripley Group, Snow Hill, North Carolina."—Gabb, 1876.

Shell rather small and thin for the genus, moderately inflated, rudely trapezoidal in outline; umbones evenly inflated, feebly prosogyrate, proximate, placed a distance of one-third to one-half of the total latitude back from the anterior margin; posterior area flattened, posterior keel obtuse; anterior lateral margin uniting with the hinge line at an angle of approximately 110°, merging into the basal margin with a very broad and sweeping curve; posterior lateral margin obliquely truncated, ventral margin horizontal medially or somewhat obliquely arcuate; external surface smooth, excepting for a microscopically fine radial lineation and a rather feeble incremental sculpture, least so upon the anterior portion, and a rather broad but shallow sulcus which follows the median line of the posterior area, becoming more feeble dorsally and gradually evanescing at the umbonal region, corresponding in position to the inner buttress of the posterior adductor; cardinal area rather low, rhomboidal, grooved with three or four concentric, diamond-shaped sulci; hinge plate presenting a straight dorsal margin, feebly arcuate ventrally; hinge teeth short, similar, transverse to the hinge line medially, approximately six in number, in the adult forms much coarser and slightly oblique or parallel to the hinge line distally; anterior muscle scar indistinct, posterior conspicuously buttressed on its inner margin; pallial line entire; inner margins not crenulated.

The casts, the form in which the species most commonly occurs in Maryland, are characterized by the evenly rounded outline, the maximum diameter falling not far from the median horizontal, the broad, low, proximate umbones and the slight obliquity of the basal and posterior lateral margins. Even the young of *C. vulgaris* are strongly oblique when occurring in the form of casts and their umbones are very much higher, narrower and more compressed. The shells of *C. carolinensis* and the young of *C. vulgaris* are quite similar in outline, but the former are much heavier and are more strongly sculptured radially.

Occurrence.—MATAWAN FORMATION. Camp U & I, Chesapeake and Delaware Canal, Delaware; Arnold Point, Anne Arundel County, Maryland. MONMOUTH FORMATION. Briar Point, Chesapeake and Delaware Canal, Delaware; Cayots Corners and Bohemia Mills, Cecil County; Brightseat and Fort Washington, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum.

Outside Distribution.—*Black Creek Formation. Exogyra ponderosa* zone of North and South Carolina. *Eutaw Formation* (Tombigbee sand). *Exogyra ponderosa* zone, *Mortoniceras* subzone, Georgia. *Exogyra ponderosa* zone, Chattahoochee River, Alabama, and (?) Booneville, Mississippi.

CUCULLÆA ANTROSA Morton

Cucullæa antrosa **Morton, 1834, Synop. Org. Rem. Cret. Group, U. S., p. 65, pl. xiii, fig. 6.**

Cucullæa antrosa **Meek, 1864, Check List Invert. Fossils, N. A., Cret. and Jur., p. 8.**

Idonearca antrosa **Conrad, 1868, Cook's Geol. of New Jersey, p. 725.**

Idonearca antrosa **Conrad, 1872, Proc. Acad. Nat. Sci., Phila., p. 54.**

Idonearca antrosa **Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 315.**

Idonearca antrosa **Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 96, pl. xiii, figs. 6-11.**

Cucullæa antrosa **Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 8.**

Cucullæa antrosa **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 391, pl. xxxii, figs. 7-9.**

Description.—" An extremely ventricose cast, marked with numerous longitudinal striæ; beaks prominent and incurved."—Morton, 1836.

Type Locality.—New Jersey.

Shell known only from cast. Outline of cast subequilateral and very globose, the maximum diameter slightly above the median line; anterior lateral margin squarely truncate medially, rounding abruptly into the dorsal and broadly into the ventral margin; posterior lateral margin slightly oblique; basal margin feebly arcuate; umbones inflated, orthogyrate, proximate, placed a little in front of the median line; hinge characters not known; buttress scar profound, extending from the pallial line to the umbonal region where it gradually evanesces.

Cucullæa antrosa Morton is well characterized by its globose outline and very prominent inflated medial umbones. It far exceeds all of the co-existent species in degree of convexity.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, Cecil County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl, New Jersey. *Monmouth Formation.* Navesink marl and Tinton beds, New Jersey. *Black Creek Formation. Exogyra ponderosa* zone of North and South Carolina. *Peedee Sand. Exogyra costata* zone of North and South Carolina. *Ripley Formation. Exogyra costata* zone. *Extreme top of zone,* Union County, Mississippi. *Selma Chalk. Exogyra costata* zone, Alabama River, Alabama.

Family ARCIDAE

Genus ARCA Linné

[Systema Naturæ, 1758, ed. x, p. 693]

Type.—*Arca noæ* Linné.

Shell equivalve, oval or subquadrate; valves closed or gaping ventrally; sculpture generally heavy and radial; hinge line long, straight, furnished with numerous transverse teeth; umbones prominent, incurved, prosogyrate, separated by a rhomboidal ligamental area scarred with cartilage grooves; margins smooth or crenulate; pallial line simple; adductor impressions subequal, strongly marked.

A genus represented by some five hundred fossil species ranging from the Silurian onward, and by about one hundred and fifty recent species widely distributed in the warmer seas from between tides to abysmal depths.

The abundance of the representatives of this genus, their wide range in time and place, together with their rather more than normal sensitiveness to environmental conditions make them of peculiar importance in stratigraphic work.

A. Latitude of adult shell exceeding 12 mm.; umbones anterior.
   1. Altitude less than one-half the latitude, valves gaping ventrally. *Arca obesa*
   2. Altitude approximately one-half the latitude; valves not gaping ventrally .... *Arca uandi*

B. Latitude of adult shell not exceeding 12 mm.; umbones submedial. *Arca saffordi*

Etymology: *Arca*, a box.

ARCA OBESA (Whitfield) Weller

Cibota obesa Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 93, pl. xi, figs. 30, 31.
Cibota obesa Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 9.
Arca obesa Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 409, pl. xxxiv, fig. 9.

Description.—" Shell small, with full and very ventricose valves, large tumid beaks situated opposite the anterior third of the length, slightly enrolled, and distant from each other as shown on the internal cast. Form of the outline trapezoidal, the length of the cast nearly twice the height, exclusive of the projection of the beaks; anterior end vertically rounded; posterior obliquely truncate; extremity obtusely pointed; basal line full, but constricted just anterior to the middle by the very marked but short and broad byssal opening; area two-thirds the length of the valve and moderately wide. On the casts the muscular imprints are very distinctly marked and of fair size, no muscular ridge; the outer margin indicating a strong and abrupt thickening of the valves with a crenulated border; radiating lines indicating moderately fine striæ show on nearly all parts of the cast, but strongest on the postero-basal section.

" The general form of this species is like a dwarfed and extremely ventricose specimen of *C. uniopsis* Conrad, but is so perfectly neat and symmetrical in its shape as to preclude the idea of a stunted individual. The valves are, however, equally ventricose, while those of that species usually are slightly unequal and sometimes very decidedly so. The form of the byssal opening is also peculiar, being broadly oval and regular instead of a long narrow slit, as is usual."—Whitfield, 1885.

A single battered cast is the sole representative of the species in Maryland.

Cibota Browne, the genus to which Whitfield assigned this species, was isolated by its author because of the presence of a byssus extruded through a gape in the ventral margin of the valves. This is not a character of even subgeneric value, since many of the true *Arcæ,* notably *A. noæ* Lamarck, the type of the genus, are byssiferous.

Occurrence.—MATAWAN FORMATION. Ulmstead Point, Anne Arundel County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—Matawan Formation. Merchantville clay marl, New Jersey.

Subgenus BARBATIA Gray

[Proc. Zool. Soc. London, 1847, p. 197]

Type.—Arca barbatia Linné.

Shell equivalve; hinge teeth numerous, small and vertical beneath the umbones, becoming larger and more oblique distally; ligamental area narrow; cartilage grooves angular, concentric.

ARCA (BARBATIA) SAFFORDI Gabb

Plate XXI, Fig. 3, 4

Arca saffordi Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 397, pl. lxviii, fig. 38 (incorrectly cited as 37).

Arca saffordi Meek, 1864, Check List Invert. Fossils N. A., Cret. and Jur., p. 9.

Trigonarea saffordi Cook, 1868, Geol. of New Jersey, p. 725.

Trigonarca (Breviarca) saffordi Conrad, 1872, Proc. Acad. Nat. Sci., Phila., p. 55, pl. ii, fig. 3.

Trigonarca (Breviarca) saffordi Gabb, 1875, Kerr, Rept. Geol. Survey of North Carolina, vol. i, App. A., p. 3.

Breviarca saffordi Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 87, pl. xii, figs. 11, 12.

Arca saffordi Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 9.

Breviarca saffordi Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 404, pl. xxx, figs. 21-24 (casts only).

Breviarca saffordi Grabau and Shimer, 1909, N. A. Index Fossils, vol. i, p. 408, fig. 527.

Description.—" Gibbous, nearly equilateral; beaks small, overhanging the area; umbones broad; area narrow and transversely striate; anterior margin narrower and straighter than the posterior, which is regularly curved; surface marked by obscure radiating and concentric lines; hinge rather broad, curved; teeth large.

" *Dimensions.*—Length .2 in.; width .26 in.; height of valve .1 in.

" *Locality.*—Hardeman County, Tennessee. Prof. Safford. Also found in the Ripley group of New Jersey."—Gabb, 1860.

Shell small, inflated; umbones rather high, convex, incurved at the tips and proximate, submedial or slightly anterior in position; outline rudely trapezoidal; anterior end broadly rounded or squarely truncate; posterior end slightly produced obliquely; base line nearly horizontal medially, evenly rounded anteriorly, obtusely angulated posteriorly; posterior area delimited by a ridge running from the umbones to the posterior ventral margin, growing increasingly obscure toward the base; hinge line straight, approximately three-fourths of the total length of the shell; hinge area quite low, rhomboidal in double valves; ligament confined to a smaller rhomb below the umbones, outlined by a rather deep linear sulcation transversely striated in slightly weathered individuals; external sculpture delicately reticulate over the entire surface with the exception of the anterior and posterior submargins; radial liræ very fine, particularly upon the posterior slope, tending to alternate in strength upon the medial area and anterior slope, numbering between forty and fifty in all; concentric lirations broader and flatter than the radial threadlets which they overrun; interspirals linear in the umbonal region, less narrow away from the umbones, thus making the interstices between the reticulate liræ more squarish in outline toward the base; hinge plate slightly arcuate ventrally; hinge teeth set in a single series, very short and straight beneath the umbones, but becoming longer and more oblique distally; number usually twenty-one to twenty-three in all, those behind the umbones exceeding by one or two those in front of them; muscle scars well defined, the posterior outlined in part by the elevated ridge in front of it; pallial line distinct, very close to the ventral margin.

Arca saffordi Gabb has been discussed chiefly from casts, so that the diagnostic characters of the surface sculpture have not been emphasized. Gabb mentions the presence of a concentric sculpture in his original description, but it seems to have been disregarded by the subsequent New Jersey paleontologists. *Arca cretacea* Conrad is, apparently, more rounded in outline, the radial sculpture is coarser and dominates the concentric, and the hinge teeth are fewer and more oblique. *A. saffordi* Gabb is the analogue in the East Coast faunas of *A. exigua* Meek and Hayden of the

Fort Pierre group of the Western Interior. *A. exigua* is a little larger than its eastern relative, quite a little higher relatively, and more inflated.

There are no generic characters by which this species can be separated from *Arca,* subgenus *Barbatia. Breviarca* was used by Conrad to include subcircular or cordiform species with numerous minute cardinal teeth arranged in a broad arc.

Occurrence.—MATAWAN FORMATION. Ulmstead Point (?). MONMOUTH FORMATION. Bohemia Mills, Brightseat, Brooks estate, McNeys Corners.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Woodbury clay, New Jersey. *Ripley Formation. Exogyra costata* zone, Hardeman County, Tennessee. *Pierre Shales.* Western Interior. *Cf. Arca exigua* Meek and Hayden.

ARCA (BARBATIA) UANDI n. sp.

Plate XXI, Figs. 5, 6

Description.—Species described from an unusually well-preserved cast of double valves. Shell of moderate size, subrhomboidal in outline; disk sinuated by a depression originating at the tips of the umbones and becoming increasingly broad and shallow toward the ventral margin; posterior area well differentiated by an obtuse angulation extending from the umbones to the posterior basal margin; anterior area less sharply defined; length of hinge line slightly exceeding three-fourths of the total length; base line made slightly flexuous by the umbonal sinus; anterior lateral margin rounding rapidly into the base; posterior lateral margin obliquely truncate; cardinal area rhomboidal, striated with two or three oblique grooves; surface of cast sculptured with about forty linear striations radiating from the umbones to the base, but absent upon the posterior and the greater part of the anterior area; characters of hinge unknown.

Dimensions.—Altitude 19 mm.; latitude 39 mm.; maximum diameter 18.1 mm.

In general outline and character of the sculpture this form suggests the much smaller *Nemodon eufaulensis* of Gabb; however, the relatively high, rhomboidally grooved hinge area militates against its reference to that genus and makes clear its affinities with the true *Arca*. The type is unique and has been described merely because it is so well characterized and because it occurs in an area where the Cretaceous bivalves are preserved only in the form of casts.

Occurrence.—MATAWAN FORMATION. Camp U & I, opposite Post 192, Chesapeake and Delaware Canal, Delaware.

Collection.—Maryland Geological Survey.

Genus GLYCYMERIS da Costa

[Brit. Conch., 1778, p. 170]

Type.—*Arca glycymeris* Linné.

Shell heavy, equivalve, equilateral or subequilateral, suborbicular; beaks almost straight, only very slightly incurved; hinge margin arcuate, set with two series of strong transverse teeth which are progressively obliterated during growth by the subsidence of the cardinal area; exterior surface of valves concentrically or radially striate; margins crenulate within; adductor scars subequal; pallial line simple or very slightly sinuous.

The genus originated in the Cretaceous, culminated in the Miocene and is represented to-day by about eighty species, widely distributed in the shallower waters of the warm and temperate seas.

GLYCYMERIS MORTONI (Conrad)

? *Pectunculus australis* Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 64. (Not *P. australis* Quoy, 1833.)

? *Pectunculus subaustralis* d'Orbigny, 1850, Prodrome de Paléontologie, vol. ii, p. 243, no. 667.

? *Axinæa subaustralis* Gabb, 1862, Proc. Acad. Nat. Sci. Phila., for 1861, p. 365.

? *Axinæa subaustralis* Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 8.

Etymology: γλυκύς, sweet; μέρις, part.

? *Axinæa subaustralis* Conrad, 1868, Cook's Geol. of New Jersey, p. 725.

Axinæa mortoni Conrad, 1869, Am. Jour. of Conch., vol. v, p. 44, pl. i, fig. 14.

? *Axinæa subaustralis* Gabb, 1876, Proc. Acad. Nat Sci., Phila., p. 317.

Axinea mortoni Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 99, pl. xi, figs. 23-25 *(ex parte)*.

Axinea alta Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 101, pl. xi, figs. 26-29.

Pectunculus australis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 10.

Axinea subaustralis Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 414, pl. xxxv, figs. 1-8. (Synonymy excluded.)

Description.—" Suborbicular, nearly equilateral, convex; beaks small, pointed, slightly prominent, central; inner margins crenulated."—Morton, 1834.

Type Locality.—Prairie Bluff, Alabama.

" Shell subcircular in outline, varying in size from 15 mm. to 40 mm. in diameter, the convexity of each valve being from one-fourth to three-tenths the diameter; very slightly oblique, the beaks central in position. The internal casts compressed about the free margin especially in adult shells, the margin strongly crenulate when well preserved. The beaks strongly elevated and pointed, their lateral slopes meeting in an angle varying several degrees either way from 90°; the impression of the hinge-plate broad and arcuate, with nine or ten strong teeth on each side of the beak, directed at nearly right angles to the inner margin of the hinge-plate, and with several smaller teeth in the middle beneath the beak. Anterior and posterior muscular impressions well defined, especially in the larger specimens. The shell substance thick, marked externally with more or less irregular, concentric lines of growth, and by regular radiating costæ which are more or less interrupted by the concentric lines upon partially exfoliated individuals. The beaks approximate and the cardinal areas small with divergent furrows."—Weller, 1907.

The species is represented, in both the Matawan and the Monmouth of Maryland, only by imperfect casts. When the dorsal margins are broken away, as they frequently are, the contour of the remainder suggests a quarter circle. The umbones are small, compressed, acutely pointed, and

subcentral, the lateral margins are straight and converge at an angle of approximately 90°, and the base line is strongly and evenly arcuate. The muscle scars are symmetrically placed near the median horizontal just ventral to the extremities of the hinge and at the base of a triangular depression which wedges out in the umbonal region. The teeth, approximately twenty in number, are small but sharp, and evenly arranged in an arcuate series. The inner margins are quite deeply crenulated.

The identity of Morton's Prairie Bluff form with Conrad's species from Crosswicks, New Jersey, is rather dubious. The Alabama form is represented chiefly by the shells, the New Jersey by internal casts. Whitfield, however, figures the exterior of a shell from New Jersey, under the name of *mortoni,* which seems to be more strongly sculptured radially than the Alabama species. He considers the southern race smaller and more nearly equidimensional than the northern, but as both forms show a considerable range of variation in size and relative proportions, this alone would hardly constitute a specific difference. Both Conrad and Meek, who noticed the casts but did not describe them, considered the two species distinct. These men were keen observers and their opinion should not be disregarded until more positive evidence is at hand for the identity of the forms.

Occurrence.—MATAWAN FORMATION. Summit Bridge, Chesapeake and Delaware Canal, Delaware; Magothy River, Anne Arundel County, Maryland. MONMOUTH FORMATION. Bohemia Mills, and right bank of Bohemia Creek near Scotchman's Creek, Cecil County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—Matawan Formation. Merchantville clay marl, New Jersey. *Monmouth Formation.* Navesink marl and Tinton beds, New Jersey. *Black Creek Formation.* North and South Carolina. *Eutaw Formation* (Tombigbee sand member). *Exogyra ponderosa* zone, Booneville, Mississippi. *Ripley Formation. Exogyra costata* zone, Georgia; Eufaula, Alabama. *Extreme top of zone,* Pataula Creek, Georgia; Chattahoochee River, Alabama. *Selma Chalk. Exogyra costata* zone, Prairie Bluff, Alabama.

Subgenus POSTLIGATA n. subgen.

Type.—Glycymeris (Postligata) wordeni.

Shell lenticular; umbones inconspicuous, submedial in position; lunule and escutcheon not defined; concentric sculpture feebly developed; ligament opisthodetic, lodged in a few grooves oblique to the dorsal margin; hine taxodont, the teeth arranged in an asymmetric but continuous series; anterior portion of the series feebly concave, the component teeth subequal and relatively large and few in number; the posterior portion of the series feebly convex and subparallel to the dorsal margin, the distal teeth larger than those beneath the umbones; adductor muscle scars subequal, two in number; pallial line simple.

Postligata shares the characters of *Glycymeris* and *Limopsis*. As in both of these genera the shell is compressed and subcircular in outline, dimyarian, and the muscle scars connected by a simple pallial line. It further suggests *Limopsis* in the asymmetric arrangement of the teeth and the discrepancies between the anterior and posterior dental series. *Postligata* is isolated, however, in the ligament characters. In *Limopsis* this is multivincular and amphidetic. In *Postligata* the ligament is alivincular as in *Glycymeris*, but placed entirely behind the umbones. Known only from the type species from the Monmouth of Maryland.

GLYCYMERIS (POSTLIGATA) WORDENI n. sp.

Plate XXI, Figs. 7-9

Description.—Shell small, subcircular in outline, lenticular; umbones small, inconspicuous, submedial, feebly inflated and feebly prosogyrate; lunule and escutcheon not defined; dorsal margins gently sloping, the anterior slope even lower than the posterior; anterior lateral margin very broadly rounded, posterior lateral margin squarely truncate; base-line strongly arcuate; external surface very finely and regularly striated concentrically from the umbones to the base with an occasional strongly defined resting stage; ligament opisthodetic, lodged in three to five short grooves oblique to the dorsal margin; hinge taxodont, the teeth V-shaped

Etymology: ***Post,*** **behind;** ***ligatus,*** **bound.**

in fresh specimens, arranged in an asymmetric but continuous series; anterior portion of the series feebly concave, the teeth subequal, approximately twelve in number; posterior portion of series feebly convex and subparallel to the dorsal margin, eighteen to twenty-two in number, the half-dozen or so beneath the umbones smaller than the others; adductor muscles two in number, subequal, situated near the median horizontal, the anterior slightly higher than the posterior; pallial line simple, distinct, rather remote from the base; inner margins non-crenate.

Dimensions.—Altitude 8.6 mm.; latitude 8.8 mm.; diameter of double valves 3.8 mm.

Type Locality.—Friendly, Prince George's County.

This species is one of the most abundant of the smaller bivalves of Prince George's County.

Occurrence.—MONMOUTH FORMATION.—Brightseat, Brooks estate near Seat Pleasant, Friendly, 1 mile west of Friendly, and McNeys Corners, Prince George's County.

Collection.—Maryland Geological Survey.

B. Schizodonta

Superfamily PTERIACEA

Family PINNIDAE

Genus PINNA Linné

[Systema Naturae, 1758, ed. x, p. 707]

Type.—*Pinna rudis* Linné.

Shell thin, fragile, byssiferous, with a fibrous external layer, nacreous within; valves inequilateral, widely gaping posteriorly, trigonal or subcuneiform in outline, non-auriculate, often mesially rostrate longitudinally; external surface usually more or less scaly, umbones terminal, anterior, acute; ligament elongated, lodged in a deep groove, hinge line straight, edentulous, muscle scars very unequal in size, the anterior small and high up beneath the beaks, the posterior relatively very large and subcentral in position; pallial line simple.

Etymology: *Pinna*, a feather.

The genus belongs to a very ancient group, prominent in the Paleozoic faunas. *Pinna* itself is not certainly known from strata older than the Jurassic. It was moderately abundant, however, during the middle and late Mesozoic, but less so, apparently, during the Tertiaries and the Quaternary. The genus is quite well represented in the warm waters of the recent seas, the byssus of some of the recent species being remarkable for its length and silky texture. That of *Pinna nobilis* Lam., of the Mediterranean, is used by the Sicilians for the manufacture of the so-called "cloth of gold," an exceedingly soft and pliable silken fabric.

PINNA LAQUEATA Conrad

Plate XXI, Fig. 12

Pinna laqueata Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser, vol. iii, p. 328.

Pinna laqueata Meek, 1864, Check List Inv. Fossils, N. A., Cret. and Jur., p. 9.

Pinna laqueata Conrad, 1868, Cook's Geol. of New Jersey, p. 725.

Pinna laqueata Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 81, pl. xvi, figs. 1, 2.

Pinna laqueata Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 10.

Pinna laqueata Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 419, pl. xxxvi, fig. 1.

Description.—" A fragment—ventricose, with eleven prominent, slender ribs; interstices concave."—Conrad, 1858.

Type Locality.—Owl Creek, Tippah County, Mississippi.

" Shell of moderate size, very rapidly expanding from the apex and ventricose, giving a subquadrangular section. Surface marked by from nine to eleven strong, simple, radiating ribs on the dorsal portion, which are broad and rounded on the top and separated by very broad concave interspaces. The lower or basal portion is marked by very strong concentric striæ parallel to the margin, so very irregular as to often form strong undulations of the surface. Line of division between the upper and lower sections of the valves very strongly marked on the cast, often presenting the appearance of a distinct suture. Posterior margin of the shell apparently double, being deeply emarginate or lobed at the line of

division between the upper and lower portions of the valve. The margin of the upper division is obliquely truncate, receding from below to the hinge line, and strongly curved inward at the central emargination. Lower section also strongly lobed and somewhat rounded.

"All the specimens seen are quite imperfect, and are more or less casts of the interior. The strong line of division between the upper and lower sections of the valve gives one the impression of a double shell, or of two distinct shells united along the margins; and were it not for the surface markings they would greatly resemble in form that of a large *Conularia*." —Whitfield, 1885.

The species is represented in the area under discussion by only the most fragmentary material, in the shape of rudely conical, longitudinally sulcate casts, some of which were at first mistaken for fragments of teeth.

Occurrence.—MATAWAN FORMATION. Post 105, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Merchantville clay marl and Woodbury clay, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey. *Ripley Formation.* *Exogyra costata* zone, Pontotoc and Union counties, Mississippi.

Family PERNIIDAE

Genus INOCERAMUS Parkinson

[Trans. Geol. Soc., London, 1819, vol. v. p. 59]

Type.—*Inoceramus cuvieri* Sowerby.

Shell fragile, of two component layers, the inner layer thin and nacreous, the outer much heavier and prismatic in texture; inequilateral and frequently inequivalved, varying in outline from subcircular to trigonal, oblong or cordate, produced transversely, obliquely or vertically; valves compressed or inflated, often unequally so; lunule and escutcheon not defined, as a rule; umbones usually more or less anterior and prosogyrate,

Etymology: ἴς (ἰν-), fibre; κέραμος, earthen-ware; probably from a fancied resemblance of the fibrous outer layer to broken pottery.

sometimes involute; posterior dorsal margins often alate or auriculate; external surface most commonly undulated concentrically, rarely smooth or radially or reticulately sculptured; ligament external, multivincular, amphidetic, lodged in a long series of similar cartilage pits placed transverse to the cardinal margin; hinge edentulous; form monomyarian in the adult state, the single large muscle impression submedial in position; pallial line entire.

There is no genus, perhaps, which is more closely identified with the Cretaceous faunas as a whole than *Inoceramus*. Although it was initiated in the Jurassic, the spectacular culmination of the group did not occur until well along in the Cretaceous, and the close of the Cretaceous apparently marked its extinction. The *Inocerami* seem to be peculiarly susceptible to changes in environment, and for that reason lend themselves remarkably well to phylogenetic studies, and a mass of detailed work has been done both in England and on the continent upon the genetic relationships of the component species. Their greatest disadvantage as a horizon marker is the fact that for the most part they are so difficult to determine with assurance.

INOCERAMUS CONFERTIM-ANNULATUS Roemer

Inoceramus confertim-annulatus Roemer, 1849, Texas, p. 402.

Inoceramus confertim-annulatus Roemer, 1852, Kreidebildungen von Texas, p. 59, taf. vii, fig. 4.

Inoceramus confertim-annulatus Conrad, 1857, Rept. U. S. and Mex. Boundary Survey, vol. i, pt. 2, p. 151, pl. v, fig. 5.

Inoceramus barabini Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 75, pl. xv. figs. 3-5. (Not *I. barabini* Morton.)

Inoceramus confertim-annulatus Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 427, pl. xxxix, figs. 2-5.

Description.—" Testa transversa, ovata, depressa, concentrice undulato-plicata et striata; plicis regularibus rotundatis confertis; intervallis latitudinem plicarum vix aequantibus; lineis elevatis tenuissimis, aequidistantibus, regularibus, et plicas et intervalla ornantibus."—Roemer, 1852.

Type Locality.—New Braunfels, Texas.

Inocerami are for the most part so difficult to determine, even from the perfect specimens, that it seems a little audacious to attempt to identify a

species from a fragment of a valve. The fragment in question, however, suggests *I. confertim-annulatus* Roemer more strongly than any other species, although it is apparently less inflated.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey. *Austin Chalk.* Texas.

Family PTERIIDAE

Genus PTERIA Scopoli

[Introd. ad Historiam Naturalem, 1777, p. 397]

Type.—*Mytilus hirundo* Linné.

Shell inequivalve, inequilateral, auriculate, anterior ear comparatively small, posterior aliform; byssal sinus under anterior auricle of right valve; exterior surface almost smooth, lamellar or striated, interior nacreous; umbones low but sharp; hinge line elongated, straight, a single cardinal tooth placed under the umbone of each valve, often supplemented by a laminar lateral tooth; ligament marginal, partially internal, partially external; pallial line entire; adductor impression subcentral.

The genus has a vast stratigraphic range, from the the Silurian onward. The recent species number about one hundred and twenty, and are limited for the most part to tropical and subtropical waters. Among them may be mentioned the Antillean pearl oyster, *Pteria radiata* Leach.

A. Base line arcuate, not approximately parallel to the dorsal margin. *Pteria petrosa*

B. Base line straight, approximately parallel to the dorsal margin. *Pteria rhombica*

PTERIA PETROSA (Conrad) Meek

Plate XXI, Fig. 10

Avicula petrosa Conrad, 1853, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. ii, p. 274, pl. xxiv, fig. 15.

Avicula linguæformis Evans and Shumard, 1854, Proc. Acad. Nat. Sci., Phila., p. 163.

Etymology: πτέρον, wing.

Avicula linguæformis Meek, 1859, Hind's Rept. Assiniboia and Saskatchewan Expl. Exped., p. 183, pl. i, fig. 7.

Pteria linguiformis Meek, 1864, Check List Inv. Fossils N. A., Cret. and Jur., p. 9.

Pteria petrosa Meek, 1864, Check List Inv. Fossils N. A., Cret. and Jur., p. 9.

Pteria linguiformis Meek, 1876, Rept. U. S. Geol. Survey Terr., vol. ix, p. 32, pl. xvi, figs. 1a-1d.

Pteria linguiformis White, 1879, 11th Ann Rept. U. S. Geol. and Geog. Survey, Territories, pp. 180, 197, 205.

Pteria linguiformis Whitfield, 1880, Geol. Black Hills of Dakota, p. 384, pl. vii, figs. 2, 3.

Pteria linguiformis Whitfield, 1885, Contributions Canadian Pal., vol. i, pt. i, p. 31.

Pteria petrosa Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 68, pl. xiv, fig. 10.

Pteria petrosa Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 429, pl. xlii,, figs. 1, 2.

Description.—" Subquadrangular, very oblique, ventricose; anterior hinge extremity sharply angulated; anterior margin obliquely subtruncated inferiorly; posterior extremity subangulated."—Conrad, 1853.

Type Locality.—Chesapeake and Delaware Canal, Delaware.

The species is represented in Maryland only by a single distorted cast, which has probably been correctly referred to this species. The form is an unusually interesting one, because of its occurrence in the Fort Pierre and Fox Hills group of the western interior and because of the presence of closely allied forms in the Cretaceous of southern India.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, Cecil County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Magothy Formation.* Cliffwood clay, New Jersey. *Matawan Formation.* Wenonah sand, New Jersey. *Black Creek Formation.* North and South Carolina. *Ripley Formation.* *Exogyra costata* zone, Alcorn County, Mississippi. *Pierre Shales.* Western Interior.

PTERIA RHOMBICA n. sp.

Plate XXI, Fig. 11; Plate XXII, Figs. 1-3

Description.—Shell rather heavy, nacreous, laminar in texture, rhomboidal in outline, inflated along a broad ridge extending obliquely back-

wards from the umbones to the posterior basal margin; umbones small, the apices acutely pointed and barely extending beyond the dorsal margin, placed within the anterior fourth, shell abruptly compressed in front of the umbones, thus forming a trigonal auricle, area behind the umbones broader and less sharply differentiated, approximately a low isosceles triangle in outline; posterior lateral margin a little longer than the posterior dorsal in the adults, a little shorter in the young, showing at all stages a broad and shallow byssal sinus; ventral margin approximately equal and parallel to the hinge line; external surface smooth excepting for incremental sculpture; ligament area narrow and much elongated, produced almost to the distal extremities of the dorsal margin, widest and feebly depressed in the umbonal region, more attenuated posteriorly than anteriorly, finely striated parallel to the cardinal margin; a single amorphous pseudo-cardinal developed in the left valve, springing from beneath the hinge margin and received in a subumbonal socket in the right valve; a single obliquely pyriform adductor impression situated a little more than half way down the oblique depression from the umbones to the posterior basal angle, a smaller scar, probably the pedal, a little behind it; a number of minute byssal pits distributed along a line running from beneath the umbones approximately parallel to the anterior lateral margin; pallial line indistinct.

Dimensions.—Altitude 40 mm.; length of hinge line 40.5 mm.; length from anterior dorsal margin to posterior ventral 60±mm.; semi-diameter 6 mm.

Type Locality.—Brightseat, Prince George's County.

The type of *Pteria rhombica* is a very striking shell. No other individuals occur which approach it in size, but a number of forms were collected at the same locality which present adolescent characters and which differ from the type only in having the posterior ventral margin a little more produced relatively and in the much smaller size, running about 15 mm. between the opposite margins and 35 mm. along the diagonal.

The species is remarkable for the regularity of the rhombic outline and the broad and uniform inflation along the diagonal.

Pteria petrosa Conrad, probably its closest relative, has a strongly arcuate basal margin, is very much less oblique and is smoothly rounded instead of being inflated merely along the diagonal.

Occurrence.—MONMOUTH FORMATION. Brightseat, and 1 mile west of Friendly, Prince George's County.

Collection.—Maryland Geological Survey.

Superfamily OSTRACEA

Family OSTREIDAE

Genus OSTREA Lamarck

[Prodrome, 1799, p. 81]

Type.—*Ostrea edulis* Linné.

Ostrea, the common oyster, is, doubtless, by reason of its great economic value, the most widely known of any of the molluscan genera. The shell is inequivalve, usually irregular and more or less inequilateral. Excepting in the larval stages it is attached by the convex left valve. The right valve, which is flattened or slightly concave, serves as a cover. The hinge is edentulous. There is a single muscle scar, the posterior, and this is subcentral. The pallial line is simple, but not well defined.

The genus has been prominent in all the molluscan faunas from the Mesozoic onward, and more than two hundred and forty species have been recognized in the Cretaceous alone.

A. Radial sculpture developed in the right valve.
- 1. Shell more or less falcate, often auriculate; radial sculpture not confined to the extreme margin of the shell nor evanescing with conspicuous abruptness.
  - a. External surface undulated or plicated.......... *Ostrea larva* s. l.
    - i. Radial plications produced into umbonal region. *Ostrea larva* var. *falcata*
    - ii. Radial sculpture not produced into umbonal region.
      - a′. Shell relatively large, auriculate, radials undulatory, not sharply plicate.... *Ostrea larva* var. *nasuta*
      - b′. Shell relatively small, often auriculate, sharply plicate............... *Ostrea larva* var. *mesenterica*
  - b. External surface linearly sulcate or finely corrugated. *Ostrea plumosa*
- 2. Radial sculpture confined to the extreme margin, evanescing away from it with conspicuous abruptness.
  - a. Outline ovate or elliptical, rarely arcuate. Ventral margin crenulated .... *Ostrea monmouthensis*
  - b. Outline arcuate-elliptical; ventral margin simple; crenulations confined to convex margin.............. *Ostrea faba*

Etymology.—*Ostrea*, the Latin word meaning "oyster."

B. Radial sculpture not developed on the right valve.
   1. Left valve radially plicated with 20-25 costæ persistent from the umbones to the margin; right valve sculptured with crowded concentric laminæ.... *Ostrea tecticosta*
   2. Left valve not radially plicate. Very heavy, spatulate. *Ostrea subspatulata*

OSTREA LARVA Lamarck

= *O. ungulata* Schlotheim.

The European form differs from the subspecies developed in America in the more elongate outline and the heavier, more numerous and more regular plications, both upon the concave and the convex margins. This tendency is so strong in some individuals that the axis of the shell may be traced as a narrow divide from the umbones to the ventral margin with strongly and regular plicated areas on either side, those of the concave margin being a little less coarse, more numerous and more rounded than those upon the convex margin.

OSTREA LARVA var. FALCATA Morton

Plate XXII, Fig. 4

Ostrea falcata Morton, 1827, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 50, pl. i, fig. 2.

Ostrea falcata Morton, 1830, Am. Jour. Sci., 1st ser., vol. xvii, p. 284, vol. xviii, pl. iii, figs. 19-20.

Ostrea falcata Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 50, pl. iii, fig. 5.

Ostrea falcata Owen, 1860, 2d Rept. Geol. Recon. of Arkansas, pl. vii, fig. 5.

Ostrea ungulata (Schlotheim) Coquand, 1869, Mon. Genre Ostrea, p. 58, pl. xxxi, figs. 11, 12 *(ex parte)*.

Ostrea larva Cook, 1868, Geol. of New Jersey, p. 375, fig.

Ostrea larva Conrad, 1868, *Ibid.*, p. 724.

Ostrea (Alectryonia) larva White, 1884, 4th Ann. Rept. U. S. Geol. Survey, p. 296, pl. xlii, fig. 8 *(ex parte)*.

Ostrea larva Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 34, pl. iii, figs. 5, 6 *(ex parte)*.

Ostrea falcata Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 11.

Ostrea falcata Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 444, pl. xliii, figs. 3-6.

Description.—" *O. falcata,* testa falciformi, auriculata, tenui; valvula superiore planulata, inferiore convexa; plicis, juxta rostrum nascentibus,

ad marginem anteriorem divaricatis; margine posteriori leviter undata." —Morton, 1827.

Type Locality.—St. Georges, Chesapeake and Delaware Canal, Delaware.

" Shell of medium size, laterally arcuate. The dimensions of an average specimen are: Length along the arcuate median line from beak to posterior extremity, 47 mm.; distance between beak and posterior extremity, 28 mm.; width of shell at middle, 16 mm.; length of hinge line, 20 mm. Shell usually more or less strongly auriculate, the ears subequal or with one ear somewhat larger than the other. Hinge line straight. Shell marked with from seven to ten deep plications which originate along the lower or convex margin and extend nearly to the beak, not leaving a conspicuous non-plicate central area, the plications towards the anterior hinge extremity decreasing regularly in size; along the upper or concave margin the shell is marked by a series of short, marginal plications. Lower valve moderately convex, with a small scar of attachment; upper valve much flatter, its plications similar to those of the lower valve."—Weller, 1907.

This large, falcate, mesially plicate subspecies of *larva* has not been found in its typical development within the Maryland lines, although it was collected at a number of localities along the Chesapeake and Delaware Canal. A few small individuals similar in size and shape to the subspecies *mesenterica* and differing from it only in the persistence of the plications to the umbonal region were collected in Prince George's County.

Occurrence.—MATAWAN FORMATION. St. Georges and Camp Fox, opposite Post 236, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Two miles west of Delaware City, Delaware; Brooks estate near Seat Pleasant and Friendly, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Marshalltown clay marl, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey. Widely distributed in the Gulf region but not differentiated.

OSTREA LARVA var. NASUTA Morton

Plate XXII, Fig. 5

Ostrea falcata var. A *(O. nasuta)*, Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 51, pl. ix, fig. 6.

Ostrea ungulata (Schlotheim) Coquand, 1869, Mon. Genre Ostrea, p. 58, pl. xxxi, figs. 6-9 *(ex parte)*.

Ostrea (Alectryonia) larva White, 1884, 4th Ann. Rep. U. S. Geol. Survey, p. 296, pl. xlii, figs. 2-5, 9 *(ex parte)*.

Ostrea larva var. *nasuta* Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 34, pl. iii, figs. 3, 4 *(ex parte)*.

Ostrea larva Hill, 1901, 21st Ann. Rep. U. S. Geol. Survey, pt. vii, pl. xlviii, fig. 66a.

Ostrea larva Hill and Vaughan, 1902, U. S. Geol. Survey, Geol. Atlas, Austin Folio, fig. 50.

Ostrea larva Veatch, 1906, Prof. Paper U. S. Geol. Survey, No. 46, pl. xi, figs. 1, 1a, 7.

Ostrea nasuta Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 447, pl. xliii, figs. 7, 8.

Description.—" Smooth, expanded, compressed; with three or four strong marginal plications."—Morton, 1834.

Type Locality.—? St Georges, Delaware.

Shell rather large for the group, thin, very brittle, compressed, laterally expanded and feebly arcuate; quite strongly auriculate, as a rule, the posterior auricle often larger than the anterior which is occasionally reduced or even atrophied; left valve only moderately convex, right valve flattened, both valves radially plicate marginally and sculptured with fine but obvious incrementals, plications broadly undulatory on the convex margin, three to seven or eight in number, reduced to marginal crenulations on the inner concave surface. Medial portion of the shell unaffected by the radials. Hinge line straight, ligament area small, trigonal, usually medial, groove shallow; muscle scar semi-elliptical, a little behind the median horizontal. Inner surface plicated in harmony with the external sculpture.

O. larva var. *nasuta* runs the longest of any of the *larva* group excepting *falcata*. It is best characterized by the very broad, only moderately deep undulations of the convex lateral margins. *O. larva* var. *mesenterica* is a smaller form, more strongly arcuate, less conspicuously auricu-

late and with sharper and more numerous plications. *O. larva* var. *falcata* is readily separated by the much sharper plications, which, unlike those of *nasuta,* persist to the umbonal region.

Occurrence.—MATAWAN FORMATION. ? St. Georges, Delaware; Gibson's Island, ? head of Magothy River, Anne Arundel County, Maryland. MONMOUTH FORMATION. Head of Bohemia Creek, Delaware; Brightseat, railroad cut west of Seat Pleasant, Brooks estate near Seat Pleasant, 1 mile west of Friendly, and McNeys Corners, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—Monmouth Formation. Navesink marl and Tinton beds, New Jersey. Widely distributed in the Gulf region but not differentiated.

OSTREA LARVA var. MESENTERICA Morton

Plate XXII, Figs. 6-8; Plate XXIII, Figs. 1, 2

Ostrea falcata var. B *(O. mesenterica)* Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 51, pl. ix, fig. 7.

Ostrea ungulata (Schlotheim) Coquand, 1869, Mon. Genre Ostrea, p. 58, pl. xxvi, fig. 10 *(ex parte).*

Ostrea (Alectryonia) larva White, 1884, 4th Ann. Rep. U. S. Geol. Survey, p. 296, pl. xlii, figs. 6, 7 *(ex parte).*

Ostrea larva Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 34, pl. iii, fig. 7 *(ex parte).*

Ostrea mesenterica Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 446, pl. xliii, figs. 9-14.

Description.—" Smooth, contracted; upper valve convex; lower valve flat; with about seven strong marginal plications; inner margin crenulated."—Morton, 1834.

Type Locality.—Shrewsbury, New Jersey.

Shell small, thin, rather brittle, arcuate laterally, more or less auriculate as a rule; lower valve feebly convex, upper valve flattened, both upper and lower valves concentrically striated by the incrementals and radially plicate; plications along convex margin vigorous, angulated or sharply

undulatory, not invading the medial portion of the shell, from three or four to seven or even nine or ten in number; radial sculpture along the concave margin reduced to marginal crenulations. Hinge area straight in auriculate individuals, rostrate when auricles are not developed; ligamentary area medial, moderately high, groove shallow; muscle scar rather small, semi-elliptical, slightly posterior in position; inner margins undulated in harmony with the external sculpture.

Ostrea larva var. *mesenterica* is the smallest and most strongly arcuate of the *O. larva* group. It is best characterized by the strongly undulated convex margin, the finely crenulated concave margin and non-plicate umbonal region.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, 1 mile west of Friendly, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Monmouth Formation.* Navesink marl and Tinton beds, New Jersey. Widely distributed in the Gulf region but not differentiated.

OSTREA PLUMOSA Morton

Ostrea plumosa Morton, 1833, Am. Jour. Sci., 1st ser., vol. xxiii, p. 293.

Ostrea plumosa Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 51, pl. iii, fig. 9.

Ostrea plumosa Meek, 1864, Check List Inv. Fossils N. A., Cret. and Jur., p. 6.

Ostrea plumosa Conrad, 1868, Cook's Geol. of New Jersey, p. 724.

Ostrea plumosa Coquand, 1869, Mon. Genre Ostrea, Terrain Crét., p. 61, pl. xxxii, fig. 9.

Ostrea plumosa Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 320.

Ostrea plumosa White, 1884, 4th Ann. Rept. U. S. Geol. Survey, p. 299, pl. xxxvii, figs. 5, 6.

Ostrea plumosa Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 31, pl. iii, figs. 12, 13.

Anomia argentaria Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, pl. iv, fig. 9.

Ostrea plumosa Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 10.

Ostrea plumosa Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 439, pl. xlii, figs. 16-18.

"*Ostrea denticulifera*" Weller, 1907, *Ibidem*, p. 436, pl. xliii, figs. 1, 2. (Not *O. denticulifera* Conrad, 1858.)

Description.—" Ovato-triangular; lower valve convex, crenated near the hinge; dorsum marked with delicate striæ, radiating with fasciculi from the beak to the margin."—Morton, 1833.

Type Locality.—? New Jersey.

Shell of medium size, extremely variable in outline, usually flattened or feebly convex and more or less constricted and falcate in the umbonal region; umbones inconspicuous, narrow, as a rule, and well over toward the posterior margin; external surface very finely sculptured radially, the ornamentation usually manifested in the form of linear sulci, frequently bifurcating and irregularly spaced; sculpture occasionally almost or altogether obsolete, particularly in the umbonal region and sometimes taking the form of fine radial corrugations; incremental sculpture quite sharp, especially on weathered surfaces; ligament area narrow, the medial depression ill-defined; submargins sharply crenulated; muscle impression elongated, often pyriform, posterior.

In *O. plumosa* Morton the natural tendency toward variation has been greatly exaggerated by weathering. The radial sculpture is restricted to a very thin surface layer, which may be decorticated without leaving any apparent scar. The outline, though variable, is usually characterized by a decided constriction in the umbonal region.

This species, so abundant and widespread in the Gulf and Western Interior, has a meager representation in Maryland.

Occurrence.—MONMOUTH FORMATION. Brightseat, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Woodbury clay, Marshalltown clay marl, and Wenonah sand, New Jersey. *Black Creek Formation.* North and South Carolina. *Peedee Sand.* North and South Carolina. *Eutaw Formation* (Tombigbee sand member). *Exogyra ponderosa* zone, *Mortoniceras* subzone, Georgia; Russell County, Alabama. *Ripley Formation. Exogyra ponderosa* zone, Georgia; Bullock County, Alabama; Clay, Lee and Chickasaw counties, Mississippi. *Exogyra costata* zone,

Georgia; Chattahoochee River and Eufaula, Alabama; Chickasaw and Pontotoc counties, Mississippi. *Selma Chalk. Exogyra ponderosa* zone, Warrior River, Alabama; Tennessee. *Exogyra costata* zone, Tombigbee River, Alabama.

OSTREA MONMOUTHENSIS Weller

Plate XXIII, Figs. 4, 5

Ostrea monmouthensis **Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 442, pl. xliii, fig. 15.**

Description.—" Shell slightly oblique, subovate in outline, the dimensions of the type specimen being: length 28 mm.; width 22 mm. Upper valve depressed convex, nearly smooth, marked only by inconspicuous concentric lines of growth. Along the ventral margin the edge is folded into sharply angular teeth which do not extend as plications into the body of the shell, these tooth-like crenulations becoming smaller and at last disappearing upon the lateral margins of the shell. Lower valve not known.

" *Remarks.*—It is with some hesitation that a species of so variable a group of shells as the oysters has been proposed for a single specimen, but it has not been possible to identify it with any of the described forms, and it seems to be so distinct that it is probable that additional examples, should they be found, could be recognized without difficulty. The shell has much the general outline of the specimen referred to *O. crenulimarginata* by Whitfield, but that shell entirely lacks the characteristic denticulation of the ventral margin of this species."—Weller, 1907.

Type Locality.—Crawfords Corner, Monmouth County, New Jersey.

The species is fairly common in the Monmouth of Prince George's County at Brightseat, but strangely enough it is represented by right valves only. The form differs from the cover valve of *O. tecticosta* not only in the development of a marginal frill, but also in the heavier texture of the shell, larger size, less cuneate outline, broader, lower umbones and ligament area; and in the character of the concentric sculpture, the external surface of *O. tecticosta* being adorned with densely crowded concentric lamellæ, while that of *O. monmouthensis* is merely roughened by more or less irregular concentric striations.

Occurrence.—MONMOUTH FORMATION. Brightseat, Brooks estate near Seat Pleasant, and 1 mile west of Friendly, Prince George's County.

Collections.—Maryand Geological Survey, New Jersey Geological Survey.

Outside Distribution.—*Monmouth Formation.* Navesink marl, New Jersey.

OSTREA FABA n. sp.

Plate XXIV, Figs. 5, 6

Description.—Shell an arcuate ellipse of moderate size and moderately heavy. Right valve feebly convex, lower (left) valve not known; umbones flattened, inconspicuous; external surface roughened by irregular concentric striations; convex margin fluted by ten to twelve denticulate plications which are, however, confined to the border of the shell and abruptly evanesce away from it; concave edge feebly and irregularly crenate; ventral extremity evenly rounded; not plicated; hinge area obscure, ligament area very small, trigonal; muscle scar semi-elliptical, posterior in position.

Type Locality.—Brooks estate near Seat Pleasant, Prince George's County.

Dimensions.—Altitude, measured in straight line from tip of hinge line to dorsal margin, 34.2 mm.; maximum latitude 12. 6 mm.

The affinities of *O. faba* n. sp. are doubtless with the *O. larva* group, but it is not referable to any of the described races. It is characterized by the uniform width of the shell from the dorsal to the ventral margin, suggesting with its slightly arcuate outline a large, flattened bean or a bean pod. The radial sculpture is more restricted in its influence than in any member of the *O. larva* group, and the ventral margin more regular in its outline.

Occurrence.—MONMOUTH FORMATION. Brightseat and Brooks estate near Seat Pleasant, Prince George's County.

Collection.—Maryland Geological Survey.

OSTREA TECTICOSTA Gabb

Plate XXIV, Figs. 2-4

Ostrea tecticosta Gabb, 1860, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iv, p. 403, pl. lxviii, figs. 47, 48.

Ostrea tecticosta Meek, 1864, Check List Inv. Fossils N. A., Cret and Jur., p. 6.

Ostrea tecticosta Conrad, 1868, Cook's Geol. of New Jersey, p. 724.

Ostrea tecticosta Coquand, 1869, Mon. Genre Ostrea, Terr. Crét., p. 50, pl. xvii, figs. 10, 11.

Ostrea pusilla Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 321.

Ostrea tecticosta White, 1884, 4th Ann. Rept. U. S. Geol. Survey, p. 301, pl. l, figs. 3, 4.

Ostrea tecticosta Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 33, pl. iii, figs. 1, 2.

Ostrea tecticosta Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 10.

Ostrea tecticosta Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 443, pl. xliii, figs. 18, 19.

Description.—" Elongated, irregularly oval, arcuate; beaks acuminate, ligament area triangular, oblique; muscular impressions rather large; lower valve generally attached, deep, usually deepest along the median line, but becoming flattened towards the basal margin; surface marked by numerous prominent, imbricating ribs, radiating from the middle line and not from the beaks; upper valve not so deep as the lower; surface only marked by the usual lines of growth; upper half of the internal margins of both valves denticulate, corresponding in the lower valve with the external plications."—Gabb, 1860.

Type Localities.—Tennessee and New Jersey.

Ostrea tecticosta Gabb is well characterized by the twenty to twenty-five sharp, concentric lamellæ of the lower valve and the corrugations radiating from the median horizontal, slightly more crowded on the ventral margin, gradually becoming finer toward the dorsal margin, irregular only in the region of the scar of attachment. The muscle scar is large, ovate or semi-elliptical and posterior in position. The upper valve is smaller than the lower, flattened and ovate-cuneate in outline. Its external surface is sculptured with fine-edged concentric lamellæ similar to those developed on the lower valve but more crowded. The

radial sculpture is reduced to faint striations or is altogether absent. The umbones of both valves are high, narrow and acute, the ligament area correspondingly high.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, Cecil County; mouth of Turner's Creek, Kent County; Brightseat, Brooks estate near Seat Pleasant, Friendly and McNeys Corners, Prince George's County.

Collections.—Maryland Geological Survey, Philadelphia Academy of Natural Sciences, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Wenonah sand, New Jersey. *Black Creek Formation.* North and South Carolina. *Pee Dee Sand.* North and South Carolina. *Ripley Formation.* *Exogyra ponderosa* zone, Chattahoochee River, Alabama. *Exogyra costata* zone, Georgia; Eufaula, Alabama; Lowndes, Chickasaw, Pontotoc and Lee counties, Mississippi. *Selma Chalk.* *Exogyra costata* zone, Sumter County, Alabama; east-central Mississippi.

OSTREA SUBSPATULATA Forbes

Plate XXIII, Fig. 3; Plate XXIV, Fig. 1

Ostrea subspatulata Forbes, 1854, Quart. Jour. Geol. Soc., London, vol. i, p. 61, text figs., pp. 61, 62.

Ostrea subspatulata Conrad, 1857, Mexican Boundary Survey, vol. i, pt. ii, p. 155, pl. x, figs. 3a, 3b.

Ostrea subspatulata Meek, 1864, Check List Inv. Fossils N. A., Cret. and Jur., p. 6.

Ostrea subspatulata Conrad, 1868, Cook's Geol. of New Jersey, p. 724.

Ostrea subspatulata Coquand, 1869, Mon. Genre Ostrea, Terrain Crét., p. 43, pl. xxxii, figs. 1-3.

Ostrea subspatulata Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 320.

Ostrea subspatulata White, 1884, 4th Ann. Rept. U. S. Geol. Survey, p. 301, pl. xxxvii, figs. 1, 2.

Ostrea subspatulata Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 32, pl. iii, fig. 14.

Ostrea subspatulata Veatch, 1906, Prof. Paper U. S. Geol. Survey, No. 46, pl. xi, figs. 3, 3a.

Ostrea subspatulata Weller, 1907, Rept. Geol. Survey of New Jersey, Pal., vol. iv, p. 440, pl. xlii, fig. 15.

Description.—" Shell obovate; somewhat trapeziform; generally thick, higher than wide; narrower at the dorsal than at the ventral or basal end,

which is turned downwards at an obtuse angle; somewhat foliaceous externally; muscular impression placed very near the base."—Forbes, 1854.

Type Locality.—Lewis' Creek, South Washington, North Carolina.

Shell large and very heavy; increasing, *Unio*-like, in thickness toward the umbones; outline ovate, subspatulate, the curvature along the horizontal axis much higher on the inner surface than on the outer, because of the thickening toward the dorsal margin; inner surface in some individuals almost flat, in others deeply convex, the margins upturned in both the horizontal and vertical planes; component layers of shell very distinct when the external surface is slightly decorticated, as it almost invariably is in the fossil oysters; ten or twelve such layers discernible in a rather large left valve, much more closely spaced toward the ventral margin; prismatic texture very obvious, the prisms set normal to the surface of the shell; umbines conspicuous by reason of their solidity, subcentral, orthogyrate or opisthogyrate, sometimes directed almost at right angles to the hinge line by reason of the increment in the umbonal region; hinge area usually wider than high, the medial area more produced ventrally, wider than either of the lateral areas, cut off from them by the slightly raised margins and the change in the direction of the growth lines; muscle scar large, pyriform, concentrically striated, placed in front of the horizontal flexure, its maximum dorsal extension below the median horizontal, its maximum anterior extension approximately coincident with the medial vertical.

Ostrea subspatulata Forbes is very rare in Maryland. It is an unusually well characterized species, especially for an oyster, and stands apart from all the co-existent species by reason of its large size, spatulate outline and heavy umbones.

Occurrence.—MONMOUTH FORMATION. Brooks estate near Seat Pleasant, Prince George's County.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* ? Wenonah sand, New Jersey. *Pee Dee Sand. Exogyra costata* zone. *Extreme top of zone,*

North and South Carolina. *Ripley Formation.* *Exogyra costata* zone, Georgia; Eufaula, Alabama. *Nacatoch Sand.* Arkansas. *Arkadelphia Clay.* Arkansas.

Genus EXOGYRA Say

[Am. Jour. Sci., 1st ser., vol. ii, 1820, p. 43.]

Type.—*Exogyra costata* Say.

"*Shell* inequivalve, inequilateral; *cicatrix* one, large, deeply impressed subcentral; *inferior valve* convex, attached, umbo spiral, spire lateral, prominent, hinge with two parallel, transverse grooves; *superior valve* discoidal, operculiform, umbo not prominent, revolving spirally within the margin, hinge with a single groove on the edge."—Say, 1820.

This genus, by reason of its ponderous lower valve and considerable abundance, is the most conspicuous element in the Upper Cretaceous faunas of Maryland, particularly those of Prince George's County. It is constantly separated from the other *Ostreidæ* by the twisted umbones and ligament pit. In Maryland it runs larger and heavier than any other member of the family and greatly exceeds them all in the discrepancy of the valves.

Douvillé,[1] in his "Observations sur les Ostréides: Origine et Classification," has advanced the theory that the *Exogyræ* were denizens of shallow waters and that the gyrate umbones and convexo-plano outline were the result of resistance to the strong, rapid currents, while the less inequivalve and inequilateral *Pycnodontæ* lay in the deeper waters out of the influence of the strong current action. The strength of this argument is somewhat vitiated by the fact that, in Maryland and more particularly in Delaware, along the Chesapeake and Delaware Canal, the two genera are commingled in great abundance.

A. External surface radially costate or cancellate at least in the umbonal region.
   1. External surface radially costate, at least in the unbonal region. *Exogyra costata*
   2. External surface cancellate in the umbonal region. *Exogyra costata* var. *cancellata*

B. External surface not radially costate nor cancellate.... *Exogyra ponderosa*

Etymology: ἔξω, outside; γῦρος, a circle.

[1] Douvillé, 1910, Bull. Soc. Géol. de France, 4e sér., tome x, pp. 634-645.

EXOGYRA COSTATA Say

Plate XXV, Fig. 5; Plate XXVI; Plate XXVII, Figs. 1, 2

Exogyra costata Say, 1820, Am. Jour. Sci., 1st ser., vol. ii, p. 43.

Exogyra costata Morton, 1828, Jour. Acad. Nat. Sci., Phila., 1st ser., vol. vi, p. 85, pl. vi, figs. 1-4.

Exogyra costata Morton, 1830, Amer. Jour. Sci., 1st ser., vol. xvii, p. 284.

Exogyra costata Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 55, pl. vi, figs. 1-4.

Exogyra costata Troost, 1840, Fifth Geol. Rept., Tennessee, p. 46.

Exogyra costata Roemer (?) 1849, Texas, p. 396.

Exogyra costata Roemer (?) 1852, Kreide. von Texas, Bonn, p. 72.

Exogyra costata Conrad, 1857, Rept. U. S. and Mex. Bound. Survey, vol. i, pt. 2, pp. 154, 155, pl. ix, figs. 2a, 2b, pl. x, fig. 1.

Exogyra interrupta Conrad, 1858, Jour. Acad. Nat. Sci., Phila., 2d ser., vol. iii, p. 330, pl. xxxiv, fig. 15.

Exogyra costata Emmons, 1858, Rept. North Carolina Geol. Survey, p. 278, fig. A.

Exogyra costata Owen, 1860, Second Rept. Geol. Recon., Arkansas, pl. vii, fig. 4.

Exogyra costata Meek, 1864, Check List Inv. Fossils, North America, Cret. and Jur., p. 6.

Exogyra costata Cook, 1868, Geol. of New Jersey, p. 374, fig.

? *Ostrea torosa* Coquand, 1869, Mon. du Genre Ostrea, Terrain Crét., p. 38, pl. xiv, figs. 1-4; pl. xv, figs. 1, 2 *(ex parte)*.

Exogyra costata Stoliczka, 1871, Mem. Geol. Survey India. Pal. Ind., Cret. Faunas Southern India, vol. iii, p. 461, pl. xl, figs. 1-3; pl. xli, fig. 1.

Exogyra costata Gabb, 1876, Proc. Acad. Nat. Sci., Phila., p. 323.

Exogyra costata White, 1884, Fourth Ann. Rept. U. S. Geol. Survey, p. 304, pl. lvii, figs. 1, 2.

Exogyra costata Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, pp. 39-41, pl. vi, figs. 1, 2 *(ex parte)*.

Exogyra costata Say, 1896, Bull. Amer. Pal., vol. i, p. 291 (No. 5. p. 21).

Exogyra costata Hill, 1901, Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, pl. xlvii, figs. 1, 1a.

Exogyra costata Hill and Vaughan, 1902, Geol. Atlas of U. S., U. S. Geol. Survey, Austin folio, illustration sheet, fig. 52.

Exogyra costata Böse, 1906, Bol. Mexico Inst. Geol., No. 24, pp. 51-54, pl. vi, fig. 3, pl. vii, fig. 1; pl. viii, figs. 2, 3; pl. ix, fig. 3.

Exogyra costata Veatch, 1906, Prof. Paper U. S. Geol. Survey, No. 46, pl. xi, figs. 2, 2a.

Exogyra costata Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, pp. 456-458, pl. xlvii, fig. 1.

Exogyra costata Stephenson, 1914, Prof. Paper U. S. Geol. Survey, No. 81, p. 50, pl. xvi, figs. 3, 4; pl. xvii, figs. 1, 2; pl. xviii; pl. xix, figs. 1-4; pl. xx, fig. 1.

Description.—"*E. costata, apex* lateral, with about two volutions; *inferior valve* convex, costate, transversely corrugated; costæ of the disk somewhat dichotomous, sometimes fornicated; *within,* a single profound cicatrix placed rather nearer to the inner side; *hinge* with two nearly parallel, profoundly excavated grooves, of which the inner one is shorter, and corrugated; *superior valve* flat, slightly concave, destitute of costæ, outer half exhibiting the increments, outer edge abruptly reflected from the inferior surface to the superior, but not elevated above it; *hinge* with a single groove on the edge; cicatrix profound. Length four inches, breadth three and a half. [Cabinet of the Academy of Natural Sciences. —Peale's Museum.] This interesting shell is the largest and most perfect of its class which has yet been found in the Ancient Alluvial deposit of New Jersey. It is not uncommon. I have seen may specimens. They vary somewhat in the costæ, being sometimes almost antiquated, sometimes nearly smooth. The aged shells became extremely thick and ponderous."—Say, 1820.

The representatives of the species occurring in the middle Atlantic States are much less strongly costate than those of the Gulf. In the majority of adults found in Maryland the radial sculpture does not persist beyond the dorsal half of the shell, and even within that restricted area it does not heavily corrugate the shell as in the typical southern *E. costata.* Indeed, the differences are so obvious and so constant that a subspecific separation would not seem amiss, but in that case, the New Jersey and Maryland race must be regarded as typical.

Stoliczka has reported the form from the Ootatoor group of southern India supposed by him to be correlated with the Cenomanian and lower Pläner of Europe. Judging from the figures, however, the Indian form is less convex and ponderous than the American, with a more regular outline and a less regular sculpture. It would be interesting, indeed, if this highly specialized form should occur in India, since it is not known either from the western United States or from the European continent.

Occurrence.—MATAWAN FORMATION. Post 157 and Post 133, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Two miles west of Delaware City, on John Higgins farm, Post 156, Briar

Point, Chesapeake and Delaware Canal, Delaware; head of Bohemia Creek and Bohemia Mills, Cecil County; Brightseat, railroad cut 1 mile west of Seat Pleasant, Brooks estate near Seat Pleasant, 1 mile west of Friendly, Prince George's County, Maryland.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum, Geological Survey of India.

Outside Distribution.—*Monmouth Formation.* Navesink marl, Red Bank sand, and Tinton beds, New Jersey. In the eastern Gulf region the species is generally distributed through the zone of *Exogyra costata,* which includes the Ripley formation (typical marine beds) of northern Mississippi, approximately the upper one-half or two-thirds of the Ripley formation (typical marine beds) of eastern Alabama and Georgia. In the Carolinas the species occurs throughout the Peedee sand. In Arkansas the species ranges through the Malbrook marl, the Nacatoch sand. and the Arkadelphia clay. In Texas the species is a common fossil in the Navarro formation and its equivalent the "Webberville" formation. In Mexico the species occurs in the Cardenas division of the so-called lower Senonian. *Ootatoor Formation.* Southern India.

EXOGYRA COSTATA var. CANCELLATA Stephenson

Plate XXVII, Fig. 3

Exogyra costata var. *cancellata* Stephenson, 1914, Prof. Paper, U. S. Geol. Survey, No. 81, p. 53, pl. xx, figs. 2-4; pl. xxi, figs. 1, 2.

Description.—" Shell of adult moderately thick; subcircular to subovate in outline; dimensions of an average specimen, length 92 mm., height 89 mm., convexity 41 mm.; dimensions of a rather large specimen, length 117 mm., height 123 mm., convexity 58 mm. Left or lower valve much larger than right valve and strongly convex; attached in proximity of beak to an external object, the beak usually somewhat deformed by the scar of attachment; general form, hinge characters, and other internal shell characters essentially the same as in *Exogyra costata* Say; surface of shell ornamented with more or less distinct, low, bifurcating, nodular costæ, the nodes produced by concentric depressions regularly arranged in such

a manner as to give to the surface of the shell a checkered or cancellated appearance; the nodes on the costæ are in some specimens more prominently connected concentrically than in the direction of the radiating costæ, thus producing distinct concentric ridges, in non-typical specimens the costæ are weakly developed and there is a corresponding strong development of concentric growth lamellæ; in adult specimens the costæ, apparently without exception, become faint and disappear in the direction of the margin, there being an area bordering the margin, varying in width, on which concentric imbricating lamellæ form the only ornamentation; extending from the beak to the posterior margin in a curve corresponding to the spiral twist of the shell there is a more or less distinctly defined, shallow, depressed area which broadens gradually in the direction of the margin; along the posterior margin of this depression, which perhaps corresponds to the umbonal ridge in *Exogyra costata* Say, the radiating costæ repeatedly bifurcate, those in front of this margin extending downward in the direction of the lower margin of the shell and those behind the margin extending upward in a rather sharp curve to the upper posterior margin of the shell. Upper or right valve operculiform, roughly ovate in outline and inclosed within the projecting margin of the lower valve; usually distinctly concave on outer surface and convex on inner surface; hinge and other internal characters essentially the same as in *Exogyra costata* Say; beak depressed, not prominent, with nearly flat spiral twist or coil; surface ornamented with numerous concentrically arranged sharp-edged lamellæ, separated by deep narrow depressions, the lamellæ being more prominent toward the outer margin of the shell, the inner, strongly concave portion of the surface being nearly smooth; costæ either absent or but very faintly developed toward postero-dorsal margin.

Remarks.—This variety has not previously been differentiated from the typical form of the species. However, it possesses a distinctive ornamentation, always recognizable, which justifies its recognition as a variety; there is even a suggestion that the form developed parallel to rather than from *Exogyra costata* Say, in which case it should, perhaps, be given specific and not varietal rank."—Stephenson, 1914.

This subspecies is particularly characteristic of the Canal and the vicinity of Bohemia Mills, where it occurs very much more abundantly than the normal type of the species.

Occurrence.—MATAWAN FORMATION. Two miles west of Delaware City, on John Higgins farm, Post 236, Camp Fox, Post 208, Post 192, Camp U & I, Post 136 and Post 133, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Head of Bohemia Creek, Bohemia Mills, and ? mouth of Turner's Creek, Kent County, Maryland.

Collections.—Maryland Geological Survey, U. S. National Museum, Philadelphia Academy of Natural Sciences.

Outside Distribution.—*Monmouth Formation.* ? Navesink marl, New Jersey.

"This variety makes its first apearance approximately coincident with the initial appearance of the typical, strongly costate forms; that is, at the base of the zone of *Exogyra costata;* it has not been found in association with typical specimens of *Exogyra ponderosa* Roemer. In the lowermost beds of its stratigraphic range, especially in Mississippi, it appears to exceed in numbers the typical costate forms. In the successively higher beds it appears to decrease in numbers, and it is absent, so far as known, from the upper 80 or 100 feet of strata in Mississippi and western Alabama, and probably from a somewhat greater thickness in the Chattahoochee region. In the Carolinas the form occurs in the Peedee sand, the known localities being near the base of that terrane; that is, near the base of the zone of *Exogyra costata.* In Arkansas the variety occurs abundantly in the Malbrook marl. In Texas the variety has been obtained from three localities, all of which are probably near the base of the Navarro formation. The first locality is one-half mile north of Cooper, Delta County, and the second and third are 4 and 4½ miles, respectively, east of Crandall, Kaufman County. Three typical specimens of this variety, brought from Mexico in 1906 by Dr. T. W. Stanton, were given to him at San Luis Potosi and were said to have been collected from a locality near Ciudad del Maiz, State of San Luis Potosi."—Stephenson, 1914.

EXOGYRA PONDEROSA Roemer

Exogyra ponderosa Roemer, 1849, Texas, p. 395.
Exogyra ponderosa Roemer, 1852, Kreide. von Texas, p. 71, pl. ix, figs. 2a, 2b.
Exogyra ponderosa Shumard, 1854, Marcy's Exploration Red River, Louisiana, p. 178.
Exogyra costata (var) Conrad, 1857, U. S. and Mex. Bound. Survey, vol. i, pt. 2, p. 154, pl. viii, fig. 3; pl. ix, fig. 1.
Ostrea torosa Coquand, 1869, Mon. du Genre Ostrea, Terrain Crét., p. 38, pl. ix, figs. 1-3 *(ex parte)*.
Exogyra ponderosa Credner, 1870, Zeitschr. deutsch. geol. Gesell., vol xxii, p. 229.
Exogyra ponderosa White, 1875, Rept. Geog. and Geol. Surveys W. 100th Mer., vol. iv, p. 172, pl. xiv, figs. 1a-1c.
Exogyra ponderosa White, 1884, Fourth Ann. Rept. U. S. Geol. Survey, p. 306, pl. l, figs. 1, 2.
Exogyra costata Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 39, pl. vi, figs. 1, 2 *(ex parte)*.
Exogyra ponderosa Stanton, 1893, Bull. U. S. Geol. Survey, No. 106, p. 65, pl. vii, figs. 1, 2.
Exogyra ponderosa Hill, 1901, Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, pl. xlv, fig. 1.
Exogyra ponderosa Hill and Vaughan, 1902, Geol. Atlas U. S. Geol. Survey, No. 76, illustration sheet, fig. 46.
Exogyra ponderosa Veatch, 1906, Prof. Paper U. S. Geol. Survey, No. 46, pl. ix.
Exogyra ponderosa Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 458, pl. xlvii, fig. 2 ?
Exogyra ponderosa Stephenson, 1914, Prof. Paper, U. S. Geol. Survey, No. 81, p. 46, pl. xiii, figs. 5-7; pl. xiv; pl. xv, figs. 1-3.

Description.—" Testa 6″ longa, 5″ lata, 4″ alta, grandi, crassa, ovata; valva maiore inflata, gibbosa, obtuse carinata, concentrice imbricato-lamellosa; valva minore incrassata, concentrice lamellosa."—Roemer, 1849.

Type Locality.—New Braunfels, Texas.

Description.—" Shell of adult very thick and ponderous, in outline subcircular to extended subovate; dimensions of an adult individual, length 111 mm., height 177 mm., convexity 94 mm.; dimensions of a medium-sized specimen, length 97 mm., height 112 mm., convexity 60 mm. Left or lower valve much larger than right valve, strongly convex; attached in proximity to beak to external object, this part of the shell often very

much deformed by scar of attachment; apical portion of shell spirally coiled within the marginal outline of the shell; hinge with ligamental groove broad, deeply impressed, paralleled on the upper side by a rather faintly developed, narrow, shallow groove, both grooves curved to conform to spiral twist of shell; posterior to the larger groove a broad, shallow, pitted or striated depression; surface of shell marked by thin, rather prominent concentric, imbricating growth lamellæ, with intermediate fine growth lines; costæ either entirely absent or small, regularly arranged costæ present in proximity to beak and extending back from beak one-half to three-fourths inch, or, in addition to the preceding, very faint irregular costæ extending back to varying distances away from beak; a more or less clearly defined umbonal ridge extends from the beak backward, in a curve conforming to the spiral twist of shell, to the lower posterior margin, usually, however, becoming rounded and less clearly recognizable toward the margin. Upper or right valve flat or slightly concave, operculiform, subcircular or subovate in outline, with a nearly flat, spiral twist, the beak being well within the margin; beak depressed, not prominent, this valve enclosed within and slightly depressed below the projecting margin of the lower valve; hinge with broad, deeply impressed ligamental groove curved to conform to the spiral twist of shell, the upper margin of the groove finely crenulated; posterior to the groove a striated protuberance occupies a position in apposition to the similarly striated depression on the left valve; in proximity to the beak the surface is marked by numerous fine, concentric growth lines, which away from the beak toward the margins are produced into thin projecting lamellæ, separated by deep, narrow depressions."—Stephenson, 1914.

The massive type of *Exogyra ponderosa,* which is so abundant and so characteristic of certain horizons in the Gulf, has not been collected in Maryland. The few individuals referred to this species are no heavier than the *E. costata,* and differ from it only in the absence of all traces of radial sculpture.

Occurrence.—MATAWAN FORMATION. Old water-filled marl pit just east of Post 236, Chesapeake and Delaware Canal, Delaware.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, U. S. National Museum.

Outside Distribution.—*Matawan Formation.* Marshalltown clay marl, New Jersey.

"In the Chattahoochee region (Alabama, Georgia) the species makes its first appearance near the base of the Tombigbee sand member of the Eutaw formation. It is common in the upper one-fourth to one-half of the Tombigbee sand in western Georgia, Alabama, and as far north in Mississippi as Monroe or Itawamba County, and in that part of the Tombigbee sand which in northern Mississippi represents the time-equivalent of the basal part of the Selma chalk. From the Tombigbee sand it ranges upward to about the middle of the Selma chalk, where the latter is most fully developed in western Alabama and east-central Mississippi; and is present in the corresponding non-chalky marine equivalents of the lower half of the Selma chalk in eastern Alabama and in Georgia, these equivalents constituting the lower one-third or one-half of the Ripley formation of this region. In North Carolina the species occurs in the upper marine invertebrate-bearing beds of the Black Creek formation. In Arkansas and northeastern Texas the species occurs abundantly in the Brownstown marl. In Texas the species is abundant in places in the upper part of the Austin chalk and in the lower part of the overlying Taylor marl; it is also fairly abundant in places in the Anacacho formation which is the time-equivalent in southwestern Texas of part or all of the Taylor marl."—Stephenson, 1914.

Genus GRYPHAEA Lamarck

Type.—*Gryphæa angulata* Lamarck.

"Coq. libre, inéquivalve, ayant la valve inférieur concave, terminée par un crochet saillant en-dessus, courbé en spirale involute, et la valve supérieur plus petite, operculaire. Chanière sans dent. Nul fossette cardinale oblongue et arquée. Nul seule impression musculaire dans chaque valve."—Lamarck, 1801.

Etymology: γρυπός, **hook-nosed.**

Subgenus PYCNODONTE Fischer de Waldheim
[Bull. Soc. Moscow, vol. viii, 1835, p. 118, pl. i, fig. 20]

Type.—*P. radiata* Fischer de Waldheim. = *Ostrea vesicularis* Lamarck.

" Shell free, regular, inequivalve, auriculate. Right valve more or less inflated, its summit inclined on the left valve, which is flat. Hinge almost straight, ornamented on both sides of the elongated cardinal fosset with numerous parallel denticulate corrugations. The fosset of the right valve is deep and directed toward the interior, that of the left valve less deep, triangular and turned outward."—Fischer de Waldheim, 1835.

The subgenus is characterized by the series of corrugations on either side of the ligament area.

A. Right valve not concentrically lamellated.
1. Altitude of adult shell usually exceeding 50 mm. Submarginal vermicular sculpture not conspicuously developed.
G. (Pycnodonte) vesicularis
2. Altitude of adult shell rarely exceeding 50 mm. Submarginal vermicular sculpture conspicuously developed..*G. (Pycnodonte) pusilla*
B. Right valve concentrically lamellated...........*G. (Gryphæostrea) vomer*

GRYPHÆA (PYCNODONTE) VESICULARIS (Lamarck)

. . . . Knorr, 1768, Mertw. Nat. 4, fig. 2.

. . . . Faujas, 1799, Hist. Nat. de la Monte St. Pierre de Maestricht, pl. xxii, fig. 4; pl. xxv, figs. 2, 5.

***Ostrea vesicularis* Lamarck, 1806, Ann. du Mus. Nat. Hist., vol. viii, p. 160, No. 5.**

***Ostrea vesicularis* Lamarck, 1809, Ann. du Mus. Nat. Hist., vol. xiv, pl. xxii, fig. 3.**

. . . . Smith, 1816, Strata identif. Organized Fossils, p. 7, pl. iii, figs. 5-7.

***Ostrea vesicularis* Lamarck, 1819, Animaux sans Vert., vol. vi, p. 219, No. 28.**

***Ostrea convexa* Say, 1820, Am. Jour. Sci., vol. ii, p. 42.**

***Ostrea vesicularis* Brongniart, 1822, Envir, de Paris, pl. iii, fig. 5.**

***Ostrea vesicularis* Nilsson, 1827, Petrif. Suecana, p. 29, No. 2, pl. vii, figs. 3-5; pl. viii, figs. 5, 6.**

***Gryphæa convexa* Morton, 1828, Jour. Acad. Nat. Sci., Phila. 1st ser., vol. vi, p. 79, pl. iv, figs. 1, 2.**

***Gryphæa mutabilis* Morton, 1828, Jour. Acad. Nat. Sci., Phila. 1st ser., vol. vi, p. 81, pl. iv, fig. 3.**

***Gryphæa convexa* Morton, 1830, Am. Jour. Sci., 1st ser., vol. xvii, p. 283.**

***Gryphæa mutabilis* Morton, 1830, Am. Jour. Sci., 1st ser., vol. xvii, p. 283.**

Etymology: πυκνός, dense, crowded; ὀδούς, tooth.

Gryphæa expansa Sowerby, 1831, Trans. Geol. Soc., London, 2d ser., vol. iii, pp. 349, 418, pl. xxxviii, fig. 5.

Ostrea vesisularis Deshayes, 1832, Ency. Méthod., vol. ii, p. 291.

Ostrea vesicularis Goldfuss, 1833, Petrif. germ., vol. ii, p. 23, pl. lxxxi, fig. 2. (Synonymy excluded.)

Gryphæa convexa Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 53, pl. iv, figs. 1, 2.

Gryphæa mutabilis Morton, 1834, Syn. Org. Rem. Cret. Group, U. S., p. 53, pl. iv, fig. 3.

Pycnodonte radiata Fischer de Waldheim, 1835, Bull. Soc. Imp. Nat., Moscow, vol. viii, p. 119, pl. i, fig. 20.

Gryphæa dilatata Phillips, 1835, Yorkshire, pl. vi, fig. 1.

Ostrea vesicularis Deshayes, 1836, Ed. de Lamarck, vol. vii, p. 246.

Gryphæa vesicularis Bronn, 1837, Lethæa Geogn., vol. ii, p. 264, pl. xxxii, fig. 1.

Ostrea vesicularis d'Archiac, 1837, Mém. Soc. Géol. de France, vol. ii, p. 183.

Ostrea vesicularis Dujardin, 1837, Mém. Soc. Géol. de France, vol. ii, p. 229, No. 74.

Ostrea vesicularis Hisinger, 1837, Lethæa suecica, p. 46, pl. xii, fig. 2.

Gryphæa convexa Troost, 1840, 5th Geol. Rept., Tennessee, p. 46.

Ostrea vesicularis Leymerie, 1842, Mém. Soc. Géol. de France, vol. v, p. 29.

Ostrea vesicularis d'Orbigny, 1844, Pal. du Voyage de M. Hommaire, p. 441.

Ostrea vesicularis d'Orbigny, 1846, Pal. Franc., Terr. Crét., p. 742, pl. vii, fig. 1.

Ostrea vesicularis Reuss, 1846, Die Verstein der Böhm. Kreideformat., pl. xxix, figs. 21, 22; pl. xxx, figs. 1-8.

Ostrea vesicularis Geinitz, 1846, Grundr., der Verstein, pl. xx, fig. 18.

Ostrea vesicularis Bayle, 1847, Geol. des Ponts, pl. vi, fig. 62.

Ostrea vesicularis Leymerie, 1851, Mém. Soc. Géol. de France, ser. 2, vol. iv, p. 202, pl. x, figs. 2, 3.

Gryphæa vesicularis Bronn and Roemer, 1852, Lethæa Geogn., vol. ii, pt. v, p. 264, pl. xxxii, fig. 1.

Gryphæa vesicularis Conrad, 1852, Dead Sea, pl. xviii, figs. 103, 104.

Gryphæa vesicularis Owen, 1860, 2d Rept. Geol. Rec. Arkansas, pl. viii, fig. 6.

Gryphæa vesicularis Schafhautl, 1863, Sud-Bayerns Lethæa Geogn., p. 143, pl. xli, figs. 5, 6.

Gryphæa vesicularis Meek, 1864, Check List. Inv. Foss. N. A., Cret and Jur., p. 6.

Pycnodonte vesicularis Cook, 1868, Geol. of New Jersey, p. 374, text figs.

Gryphæa vesicularis Conrad, 1868, *Ibid.*, p. 724.

Ostrea vesicularis Coquand, 1869, Mon. du Genre Ostrea, Terrain Cret., p. 35, pl. xiii, figs. 2-4, 10. (Non figs. 5-9.)

Gryphæa vesicularis Stoliczka, 1871, Mem. Geol. Survey, India, Palaeont. Indica, Cret. Faunas of Southern India, vol. iii, p. 465, pl. xlii, figs. 2-4; pl. xliii, fig. 1; pl. xlv, figs. 7-12 ?

Pycnodonte vesicularis Bayle, 1878, Expl. Carte Géol. France, vol. iv, Atlas, pt. 1, pl. cxxxv, figs. 1-7.

Gryphæa vesicularis White, 1884, 4th Ann. Rept. U. S. Geol. Survey, p. 303, pl. xlviii, figs. 1-5.

Gryphæa vesicularis Whitfield, 1885, Mon. U. S. Geol. Survey, vol. ix, p. 36, pl. iii, figs. 15, 16; pl. iv, figs. 1-3; pl. v.

Gryphæa vesicularis Nötling, 1897, Mem. Geol. Survey India, Pal., ser. xvi, vol. i, p. 39, pl. x, figs. 1, 2.

Gryphæa vesicularis Imkeller, 1901, Pal., vol. xlviii, p. 40, pl. ii, figs. 2-4; pl. iii, fig. 7-9.,

Gryphæa vesicularis Hill, 1901, 21st Ann. Rep. U. S. Geol. Survey, pt. vii, pl. xlvii, fig. 2.

Ostrea (Pycnodonte) vesicularis, Choffat, 1902, Faun. Cret. Portugal, vol. i, ser. iii, p. 103, pl. ii, fig. 18.

Gryphæa vesicularis Wanner, 1902, Pal., vol. xxx (2), p. 119, pl. xvii, figs. 10-12.

Gryphæa vesicularis Taff, 1902, 22d Ann. Rept. U. S. Geol. Survey, pt. iii, pl. l, figs. 1-3; pl. li, figs. 1, 1a; pl. lii, figs. 1, 1a.

Gryphæa vesicularis Hill and Vaughan, 1902, U. S. Geol. Survey, Geol. Atlas, Austin folio, fig. 51.

Pycnodonte vesicularis Douvillé, 1904, Mission Sci. en Perse par J. de Morgan, vol. iii, pt. 4, Pal., p. 278, pl. xxxvi, fig. 23.

Gryphæa convexa Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 11.

Gryphæa mutabilis Johnson, 1905, Proc. Acad. Nat. Sci., Phila., p. 11.

Gryphæa vesicularis Böse, 1906, Bol. Ins. Geol. Mexico, No. 24, p. 49, pl. iv, figs. 1-3; pl. vii, fig. 2; pl. ix, fig. 4; pl. xii, fig. 6.

Gryphæa vesicularis Veatch, 1906, Prof. Paper U. S. Geol. Survey, No. 46, pl. x, figs. 1-2a.

Ostrea (Gryphæa) vesicularis Boule and Thevenin, 1906, Ann. Paleont., vol. i, p. 49 (7), pl. ii, fig. 3.

Gryphæa convexa Weller, 1907, Geol. Survey of New Jersey, Pal., vol. iv, p. 451, pl. xlv, figs. 1, 2.

Gryphæa mutabilis Weller, 1907, *Ibidem*, p. 452, pl. xlvi, fig. 1.

Gryphæa dissimilaris Weller, 1907, *Ibidem*, p. 453, pl. xlvi, figs. 2, 3.

Ostrea vesicularis Woods, 1913, Palaeont. Soc., London, Mon. Cret. Lamellibranchia, England, vol. ii, pt. 9, p. 360, pl. lv, figs. 4-9; text figures 143-182.

Description.—Shell strongly inequivalve, subequilateral, as a rule, subcircular to semi-circular in outline, often more or less auriculate posteriorly; thin to ponderous; umbones central or anterior, orthogyrate, that of the left valve often strongly inflated and turned inward; left valve convex, often conspicuously so, attached in the umbonal region; right valve usually a little smaller than the left, flattened or concave; incremental sculpture well defined in both valves, the component layers so obvious in the ponderous individuals that they have the appearance of having slipped

one over the other, the free ventral edges being visible on the external surface and their dorsal edges on the interior; radial sculpture absent upon the left valve but often quite strongly developed upon the right; ligament area trigonal, the medial sulcus broad and shallow, indenting the inner margin, area of the left valve strongly undercut, that of the right valve truncated; the ligament area of the two valves forming a V-shaped trough, thus allowing the cover-valve to be opened quite widely; vermicular corrugations developed on either side of the ligament pit; muscle scar very distinct, even profound in some of the more ponderous individuals, placed a little behind the median line and quite high up.

No Upper Cretaceous group is more sadly in need of monographic treatment than that of *G. vesicularis* (Lamarck), nor does any bear promise of yielding more interesting results in general correlations. The group is world-wide in its distribution—it has been reported from the East Coast, the Gulf and the Western Interior of North America, England, Central Europe, Russia and Southern India, and is usually one of the most prominent elements in the faunas in which it occurs. This wealth of material from widely separated localities has made the problem of separating geographic from chronologic influences an exceedingly delicate one and a problem which demands for its proper solution a consideration of all the types of variation at all the occurrences. Until this can be done it seems wiser to avoid further confusing the literature by frankly evading the question, merely indicating the lines of variation followed by the Maryland Gryphæas and assigning to these subgroups the non-committal name of "races."

Five distinct races are present in Maryland, distinct in their peripheral members but with intergrading individuals.

Race A. Plate XXVIII; Plate XXIX, Fig. 1

(A) Shells of moderate size, usually very heavy, the posterior dorsal margin often produced and separated from the central disk by a broad and shallow depression; the right valve not very much smaller than the left and feebly or not at all concave. This is the *G. mutabilis* of Morton, and is the race so exceedingly abundant along the Canal, particularly at

Camp Fox, Post 236, where the shells can be collected literally by the boat-load.

Race B. Plate XXIX, Figs. 2, 3; Plate XXX, Figs. 1, 2

(B) The second race runs larger than the first and is very much less ponderous, the posterior dorsal area is usually more or less auriculate as in Race A, but the two valves are much more discrepant in size, the right valve being sometimes quite strongly concave. It is apparently one of the races included by Weller under *G. mutabilis*. Although far from rare, it is not so conspicuously abundant as Race A with which it is associated.

Race C

(C) The third race includes thin, very strongly convex shells, agreeing perfectly with Morton's figure of *G. Convexa* Say. It occurs at only a few localities and may represent a slightly higher horizon than the preceding races, although that is doubtful.

Race D. Plate XXXI; Plate XXXII

(D) The fourth race quite possibly represents a distinct species; the young are semi-circular in outline with a straight and very much elongated hinge line; the left valve is feebly convex, the right flattened; the adults and gerontic types are very large and ponderous and highly inflated; they attain an altitude of 120 mm., thus exceeding in size anything occurring along the Canal. Two young and one adult were collected at Brightseat, while a form showing the same general tendencies was found near Bohemia Mills.

Race E. Plate XXXIII, Figs. 1-3

(E) The last race includes very thin, moderately compressed equilateral shells from the Rancocas in the environs of Odessa, Delaware, which are apparently not the *G. dissimilaris* Weller from the Rancocas of New Jersey.

Occurrence.—Race A. MATAWAN FORMATION. Opposite Post 239, Camp Fox, Post 236, Post 198-199, Camp U & I, Post 192, upper and lower terranes, Chesapeake and Delaware Canal, Delaware. MONMOUTH

FORMATION. Burklow's Creek, Delaware; Cayots Corners, Jones farm, Merrit farm, Cecil County, Maryland.

Race B.—MATAWAN FORMATION. Opposite Post 239, Camp Fox, Post 236, Camp U & I, Post 192, Post 157, Chesapeake and Delaware Canal, Delaware. MONMOUTH FORMATION. Two miles west of Delaware City on John Higgins farm, Post 156, Chesapeake and Delaware Canal, Delaware.

Race C.—MATAWAN FORMATION. Camp U & I, Post 192, upper and lower terranes, Delaware. MONMOUTH FORMATION. Two miles west of Delaware City on John Higgins farm, Delaware.

Race D.—MONMOUTH FORMATION. Brightseat, Prince George's County, Maryland.

Race E.—MONMOUTH FORMATION. Mouth of Turner's Creek, Kent County, Maryland. RANCOCAS FORMATION. Noxontown Pond, south side of Appoquinimink Creek, between Odessa and the mill-dam, Delaware.

Collections.—Maryland Geological Survey, New Jersey Geological Survey, Philadelphia Academy of Natural Sciences, U. S. National Museum, Geological Survey of India.

Outside Distribution.—"*Gryphæa convexa* (Say)." *Matawan Formation.* Marshalltown clay marl, New Jersey. *Monmouth Formation.* Navesink marl, New Jersey. "*Gryphæa mutabilis* Morton." *Matawan Formation.* Marshalltown clay marl, New Jersey. "*Gryphæa dissimilaris* Weller." *Rancocas Formation.* Hornerstown marl, New Jersey.

"*Gryphæa vesicularis* Lamarck" *sensu lato. Black Creek Formation.* North and South Carolina. *Peedee Sand.* North and South Carolina. *Eutaw Formation* (Tombigbee sand member). *Exogyra ponderosa* zone, Alcorn County, Mississippi. *Ripley Formation. Exogyra ponderosa* zone, Georgia. *Exogyra costata* zone, Georgia; Tennessee; Wilcox and Pike counties, Chattahoochee River, Eufaula, Alabama; east-central Mississippi; Lee, Pontotoc, Chickasaw and Union counties, Mississippi. *Extreme top of zone,* Pataula Creek, Georgia; Chattahoochee River, Alabama. *Selma Formation. Exogyra ponderosa* zone, Tennessee; Lee, Chickasaw and Prentiss counties, Mississippi. *Exogyra costata* zone, Tombigbee River, Wilcox and Sumter counties, Alabama; Lee, Chickasaw,

Clay and Alcorn counties, Mississippi. *Pierre Shales.* Western Interior. *Senonian.* Mexico, England, France, Germany, Bohemia, Switzerland, Spain, Portugal, Belgium, Russia, Poland, Egypt, Algiers, Syria. *Arialoor Formation.* Southern India.

GRYPHÆA (PYCNODONTE) PUSILLA n. sp.

Plate XXXIII, Figs. 4-6

Description.—Shell small, solid, dwarfish in general aspect, inequivalve, slightly inequilateral; left valve moderately convex, the maximum convexity at the medial portion of the shell; right valve flattened or even inclined to be concave; umbone in the left valve anterior, evenly inflated, orthogyrate, anterior end of left valve evenly rounded, posterior end produced somewhat obliquely; ventral margin asymmetrically arcuate; right valve more regularly ovate in outline, the dorsal and the lateral margins obscurely truncate, the base line strongly arcuate; external surface smooth excepting for incremental sculpture which is most pronounced toward the ventral margins of the right valve and along the dorsal margins of the left; ligament area narrow, trigonal, the ligament groove only slightly impressed; submargins of both right and left valves sculptured with prominent crowded vermicular corrugations; the single adductor muscle scar conspicuous, above and slightly behind the median line; pallial scar distant from the ventral margin.

Dimensions.—Left valve, altitude 34 mm., latitude 37 mm., semi-diameter 13.6 mm.; right valve, altitude 39.5 mm., latitude 40.5 mm., semi-diameter 7.6 mm.

This form is remarkable for its small size and solidity, and for the prominence of the vermicular sculpture of the submargins. It may possibly prove to be a dwarfish type of *P. vesicularis* Lam., but nothing quite like it occurs in any of the abundant and varied material that represents the group in Maryland.

Occurrence.—MONMOUTH FORMATION. Bohemia Mills, Cecil County.

Collection.—Maryland Geological Survey.

DATE DUE
